A contemporaneous overview of Health Economics: informing the debate about health expenditures by introducing the impact of ICTs and innovation on healthcare

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Para todos os que acreditaram em mim, especialmente aos meus pais, com todo o meu carinho.

Nota Biográfica

Erika Ferreira Laranjeira nasceu a 6 de Novembro de 1984, Faido, Suíça. Regressou definitivamente a Portugal com os seus pais em 1992 onde passou a frequentar o ensino público Português.

Até entrar para a Faculdade de Economia da Universidade do Porto em 2003, frequentou a escola secundária Dr. João Araújo Correia em Peso da Régua.

Em 2007, termina o curso de economia e entra no mercado de trabalho nesse mesmo ano, exercendo funções de assistente em Estatística na Faculdade Católica Portuguesa em Lisboa e de economista no Ministério das Finanças e Administração Pública.

Em Setembro de 2009, decidiu dar início a uma nova fase da sua vida e inscreveu-se a tempo integral no programa de doutoramento da Faculdade de Economia do Porto, especializando-se na área de Economia da Saúde.

Após a conclusão da parte escolar do doutoramento, viu os seus papers serem apresentados em diferentes conferências a nível nacional e internacional.

Antes de terminar o seu doutoramento surgiu uma proposta de trabalho para a empresa Evigrade, Health Care Research and Consulting, Lda. o que a fez regressar a Lisboa.

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"*Deus, dai-me a SERENIDADE para aceitar as coisas que eu não posso mudar, CORAGEM para mudar as coisas que eu possa mudar, e SABEDORIA para que eu saiba a diferença*."

Sendo esta uma página opcional, irei usar a mesma para expressar o que não pude expressar explicitamente ao longo da minha tese. Por isso, esta tese é dedicada a todas as pessoas que sabem o quanto esta tese representa para mim, não a nível académico, mas sim a nível pessoal. Foi uma luta difícil, mas resisti.

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Sumário

Esta tese centra-se particularmente na área da Economia da Saúde. Todavia, a mesma pode ser decomposta em duas partes autónomas.

A primeira parte, que corresponde ao capítulo 2, é um estudo essencialmente teórico sobre o desenvolvimento do que hoje conhecemos como Economia da Saúde, dando especial atenção não só à sua origem como também ao papel desempenhado pelas novas Tecnologias da Informação e Comunicação (TICs) na Economia da Saúde e nos cuidados de saúde.

A segunda parte, que é constituída pelos capítulos 3 e 4, tem uma natureza essencialmente empírica.

No capítulo 3, determinam-se os principais fatores, que ao longo das últimas décadas contribuíram para o aumento das despesas em saúde, dando especial enfâse ao impacto das TICs no sector. Este estudo distingue-se da restante literatura através do uso de uma "base de dados completa" suportada pela múltipla imputação e através da construção de um índice tecnológico capaz de refletir o papel das TICs no sector da saúde. Os resultados obtidos permitiram concluir que o recurso a dados em painel e à múltipla imputação pode ser uma abordagem viável para a análise da tendência das despesas em saúde.

O último estudo procura não só determinar se a preocupação atual à volta do montante das despesas em saúde é realmente legítima, mas também procura avaliar o retorno de tal despesa em termos quantitativos (esperança média de vidas) e qualitativos (morbidade e incapacidade). Para tal, construiu-se um novo indicador do estado da saúde da população capaz de combinar, no mesmo indicador, mortalidade e morbidade. Recorrendo a uma vasta base de dados em painel, constituída por 30 países da OCDE, estimou-se a influência de determinadas variáveis socioeconómicas, ambientais, de estilo de vida e tecnológicas no indicador em questão.

Summary

The central theme of this thesis is within the field of Health Economics. However, we can decompose it into two independent parts.

The first part (Essay 1) is essentially a theoretical essay about the development of what we know today as Health Economics, highlighting not only its origin and its leading authors - and what they defended-, but also the role of the development of Information and Communication Technologies (ICTs) for Health Economics and Healthcare.

The second part (Essay 2 and Essay 3) has an empirical nature.

In the second essay, we determine the main factors that, over the last few decades, have contributed to the increase in healthcare spending, focusing especially on the impact of technological innovation on the healthcare sector. This essay differentiates itself from the literature by using a "complete panel dataset" supported by multiple imputation and through the construction of a technological composite index able to account for the role of new technologies in the healthcare sector. The results obtained suggest that the use of panel data and multiple imputation techniques may be a viable approach to the analysis of trends in healthcare expenditure.

The last essay tries not only to determine if the concern that nowadays surrounds healthcare expenditure is really legitimate, but also to evaluate the return of such expenditure in quantitative (life expectancy) and qualitative (morbidity and disability) terms. For that, we construct a new health status indicator able to combine mortality and morbidity into a single composite measure. Using a large panel data of thirty OECD countries, we estimate how various socio-economic, environmental, lifestyle and technological factors affect the health status indicator.

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Chapter 1

1. Introduction

The aftermath of World War II initiated a period of incredible economic growth, due in large part to a boom in technological advances and changes across virtually all sectors of the global economy. More specifically, the global healthcare system also experienced a profound transformation during this same timeframe, namely across the developed world. During this time, Developed countries managed to achieve high growth rates in total healthcare expenditures, coupled with an exponential increase in the introduction and implementation of health technologies. As such, the emergence of several drugs, supplementary means of diagnostic, and surgical equipment, invariably contributed not only to the improvement of diagnosis, treatment and the quality of information, but also to the overall growth of healthcare expenditures.

The growth of healthcare spending associated with the economic slowdown in developed countries has long since attracted the attention of people, specifically health economists (Mushkin, Lees, Arrow, among several others), organizations and policymakers, whose principal concerns were to understand and analyze such phenomena. According to the Organisation for Economic Co-operation and Development (OECD), the growth in health spending exceeded the growth of Gross Domestic Product (GDP) in almost all OECD countries over the past fifteen years and could grow by another 50 to 90 percent by 2050 (OECD, 2009). This growing interest on health sector has since led to the inception of the discipline of Health Economics as an autonomous branch within the field of economics.

Beginning in the 1960s, initial studies started to appear with the main aim to understand and restrict healthcare spending growth. Overall, these inaugural studies analyzed the influence exerted by certain measurable and non-directly measurable variables on healthcare spending. Indeed the prevailing literature has sought to study the

determinants of growth in healthcare costs through the use of different methodologies – these studies share some consistent conclusions identifying the paramount drivers responsible for this growth. For example, authors agree that the effect of income on health expenditure is positive and significant; i.e. aging population plays only a minor role in increasing cost, while the existence of 'gatekeepers' helps to reduce costs despite being routinely insignificant. Furthermore, public sector provisions of healthcare services was widely agreed to increase health expenditures, identifying technological change as the most important impetus for spending increases over time (Gerdtham and Jönsson, 2000).

However, one of the major problems surrounding the enigmatic growth of healthcare spending is the inherent difficulty in measurements of quantitative and qualitative returns of invested values. As such, there is a problem in understanding precisely how effective this spending is, asking the question: what is a plausible means of evaluating the economic return of these investments and the possible contributions of this increase relative to spending on health.

The nature and magnitude of such concerns raise some important questions about the amount of healthcare spending – from what point can we say that such expenditures are considered 'high'? Is there truly an equilibrium for health expenditure? Is this concern about healthcare sector legitimate? What in fact are the negative ramifications, if any of high healthcare costs?

This thesis is comprised of four chapters, along with an introductory chapter – the remaining chapters cover the following topics:

Chapter 2 is a background about the evolution of Health Economics as an autonomous branch within the larger field of Economics, highlighting not only its origin and the leading authors who pioneered the discipline, but also the impact and the role of the Information and Communication Technologies development on the Health Economics and healthcare sector.

The purpose of chapter 3 is to determine the main factors that, over the last few decades, have contributed to an increase in healthcare spending, with particular attention

paid on the impact of technological innovation across the healthcare sector. This study differentiates itself from the prevailing literature by using a "complete panel database", supported by multiple imputations through the construction of a technological index that are effectively able to account for the role of new technologies across the healthcare sector.

The analysis and subsequent results present both robust and interesting results, suggesting that the use of panel data and multiple imputation techniques may be a viable approach to the analysis of trends in health expenditure. Furthermore, many of our conclusions corroborated findings in the literature such as Barros (1998) and Okunade *et al*. (2004) – others results regarding the influence of technology were not relevant. The study also found that technological innovation has a differential positive impact on costs, dependent on a country's stage of development of technology, i.e. increases in the health expenditure *per capita* were driven by technological innovation, exhibiting diminishing returns,

Finally, in chapter 4, we attempt to determine if concern surrounding healthcare spending is legitimate whereby evaluating the return of such spending in quantitative (life expectancy) and qualitative (morbidity and disability) terms. For this test, we construct a new health status indicator that combines mortality and morbidity into a single composite measure.

According to the consequent analysis performed, we concluded that the concern around the amount of health care spending *per capita* should not be focused on the total expenditure *per se*, but instead directed to the amount financed by the government.

JEL classification: C87, I10, N01, O33.

Keywords: Health Economics, Healthcare Economics, Information and Communication Technologies (ICTs), Multiple Imputation, Technological Innovation, Healthcare Costs

Chapter 2

2. Why and how did Health Economics Appear? Who were the Main Authors? What is the Role of ICTs in its Development?*

* This is a joint paper with Ana Pinto Borges and it was published in "Handbook of Research on ICTs and Management Systems for Improving Efficiency in Healthcare and Social Care", edited by Maria Manuela Cruz-Cunha, Patrícia Gonçalves and Isabel Miranda, IGI Global.

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2.1 Introduction

The end of World War II signaled a new era in technological innovation and economic growth that permeated virtually all sectors of the world economy. One such sector that yielded an extraordinary transformation in this regard was the Healthcare system.

Developed countries thus experienced not only abrupt advances in medical knowledge, but also the genesis of Information and Communication Technologies (ICTs) in the health sector, which instigated numerous changes in management and political beliefs. Such changes were also reflected in their respective national accounts which attracted the attention of several institutions and economists (Mushkin, Lees, Arrow, among several others), with the aim of disseminating the mechanisms behind this phenomenon, thus paving the way for the emergence of health economics as sovereign field within the overarching mantle of economics. According to the Organisation for Economic Co-operation and Development (OECD), growth in health spending exceeded growth of Gross Domestic Product (GDP) in almost all OECD countries over the past fifteen years and could grow by another 50 to 90% by 2050 (OECD, 2009).

In this chapter, we focus on the origins and subsequent development of Health Economics as a social science, reflecting on the role played by leading authors that emerged in the field, while also tracing the development of ICTs across health economics and healthcare. In this sense, it is worth noting that in the last few decades, there have been substantial increases in the utilization of health technologies, as well as the emergence of myriad drugs, and supplementary means of diagnosis and surgical equipment, among others.

Indeed, the aggregative effect of innovation on the health sector allowed for different entities such as governments, healthcare providers, and patients to collectively reap the benefits from a cascade of higher-quality health services. However, despite all the latent advantages associated with the introduction and implementation of these innovations,

the use of ICTs across the health sector itself still remains largely limited in several areas, due in large part to the existence of some barriers inherent to the sector.

The next chapter is organized as follows: Section 2.2 outlines the origin of health economics along with the acute differences between health economics and healthcare economics. In section 2.3, we explore the development of ICTs and its role in the health economics sector, coupled with the limited use of ICTs – the final section offers concluding remarks.

2.2 The Origin of Health Economics and the Leading Authors

Issues related with the quality, effectiveness, and overall efficiency of the health sector, notably with respect to the level of costs, has been a familiar theme in the political agenda of many countries. This growing trend, which when verified by mounting health expenditures, attracted the attention of different academics and researchers, with the singular aim of pinpointing the underlying causes of this rampant growth and the hopes of controlling for such phenomenon (Mehrotra *et al.*, 2003).

Seemingly runaway healthcare costs across several regions also drew the attention of some organizations such as the Institute of Economic Affairs[1] in London and the Ford Foundation[2], raising notable concern amongst policymakers. It is important to note that the existence of high healthcare costs did not in and of itself elicit the concern of these individuals, but rather a runaway effect in the nature of rising prices themselves.

[1] The Institute of Economic Affairs is a United Kingdom's original free-market police institute, founded in 1955. Its mission is to improve understanding of the fundamental institutions of a free society by analyzing and expounding the role of markets in solving economic and social problems.

[2] The Ford Foundation is a private foundation incorporated in Michigan and based in New York City by Edsel Ford and Henry Ford to "*receive and administer funds for scientific, educational and charitable purposes, all for the public welfare*".

Researchers can generally mark the period immediately following World War II as the beginning of ascending health spending in most of the world's industrialized countries. Some works done in the area attribute a large portion of the growth observed in health spending to substantiated advances in medical knowledge, as new medical procedures and drugs (Cutler, 1995; Matteo, 2005; Okunade and Murthy, 2002). Indeed, the introduction of new and sophisticated medical technology is hardly an isolated occurrence, namely as initial expenses and installation costs of new equipment in the medical high has historically been rather high.

According to some forecast studies, the emergence and consequent adoption of new medical technologies and services were the paramount factors responsible for such growth, constituting roughly half of the increase witnessed in healthcare expenditures during the past few decades. For Cutler (1995) the adoption of new technology in the healthcare sector has contributed in a 45% increase in the total growth of real healthcare spending *per capita* in the USA between 1940 and 1990. In turn, Newhouse (1992) estimates an increase over 65%.

It was in this social, political, and economic context that, in 1948 the National Health Service (NHS) – a program for health – was created in England, which served as a watershed year for the field of health economics in that several other countries followed shortly after. The NHS' core principles were: universal coverage and equitable access according to need.

However, over time the increased availability of drugs, such as antibiotics (developed by Fleming in 1928 and Florey and Chain in 1939), better anaesthetics, the use of insulin in the treatment of diabetes (Banting and Best, 1922), effectively helped drive up the costs incurred by the NHS. These increases were further compounded by the more widespread offerings of cortisone, the polio vaccine, treatments of mental illnesses such as depression, antihistamines, as well as all other advances (including improved radiology systems, dialysis for chronic renal failure, and chemotherapy, among many others, which collectively threatened to jeopardize the service's overall mission.

At this same time, the United States faced similar issues of its own, leading to the establishment in 1965, of a social insurance program designed to provide for the needs of all elderly adults through the availability of comprehensive healthcare coverage at an affordable cost – tabbed as the Medicare system. This program and its sister program, Medicaid, were enacted by President Lyndon Johnson as part of his "Great Society", a period of widespread social change. In 1972, Medicare eligibility was extended to two other groups as well, helping individuals who also faced similar barriers in obtaining reliable health coverage – people with disabilities and people with terminal renal disease.

As early as the 1950s and 1960s, healthcare established itself as a central economic issue worldwide. It was also during this same time period that several publications became commonplace, attempting to explain and analyse the system itself. With a renewed focus on its citizenry in the aftermath of the Second World War, politicians and economists' speeches began to reflect a marked improvement in public health thorough the targeted reduction of disease, debilitation and premature mortality, with the aim of promoting economic growth through the preservation and strengthening of their respective workforce. This ideology was also associated with the rationalization, conceptualization, and professionalization of health, which helped launch the emergence and proliferation of global health organizations.

According to Mushkin (1958), this growing interest in the health sector coincided with the need to respond to emerging problems handicapped by issues of financing and with two developments that were both inherent to scientific advances in medicine. First, new therapeutic products helped combat diseases that served as an ever-present spectre contributing to the leading causes of death in countries such as the US and other industrial nations. Furthermore, countries actively sought to address the possibility of increasing life expectancy.

Mushkin (1958) was the first person to write about health economics having also provided the first concrete definition of the field, this is, Health Economics "*is a field of inquiry whose subject matter is the optimum use of resources for the care of sick and promotion of health. Its task is to appraise the efficiency of the organization of health services and to suggest ways of improving this organization*" (Mushkin, 1958, pp. 790). In

1958, she published her paper, *Toward a Definition of Health Economics*, in Public Health Reports, and outlined the difference between medical market and the classical economics market.

The main ideas to distinguish the medical market and classical economics market were: "*First, the profit motive is not adequate as an explanation of the activity in medical "market"… Second, in medicine, price is not the sole means by which demand and supply of medical and health services may be equated…Third, medical services are personal services…Fourth, consumers do not choose between health services and other goods and services by means of a simple rational weighing of choice…the consumer prefers to avoid, or remove the circumstances that compel, using resources for health purposes."*(Mushkin, 1958, pp. 786-787).

Other publications of note included a British study through the Institute of Economic Affairs, in the form of a Hobart Paper by Dennis Lees (1961) called *Health through Choice* that voiced the first concerns over health in the economy (Williams, 1998). Later, the most important of Lees' ideas presented in that paper were adopted in the US by Arrow's famous 1963 American Economic Review article, *Uncertainty and Welfare Economics of Medical Care*, and then later by Culyer in Britain (Williams, 1998).

Arrow (1963), considered by many to be the founder of health economics, wrote about several issues that characterize this research field itself, such as the role of uncertainty on the effectiveness of healthcare, the agency problem both between doctor and patient and between doctor and health insurance and physician's behavior, risk aversion, moral hazard, asymmetrical information, and philanthropic externalities, among many other issues.

Arrow's principal objective was to show that the healthcare market differed from the competitive model that maximized welfare. He called particular attention to the fact that the "*... subject is the medical-care industry, not health. The causal factors in health are many, and the provision of medical is only one. Particularly at low levels of income, other commodities such as nutrition, shelter, clothing, and sanitation may be much more*

significant. It is the complex of services that center about physician, private and group practice, hospitals, and public health..."(Arrow, 1963, pp. 941).

Despite the first reference made by Lees (1961) and the fact that the ideas developed by Mushkin (1958) were quite close to the main ideas present in Arrows' paper entitled, "*Uncertainty and the Welfare Economics of Medical Care*", the foundation of Health Economics as a discipline is still attributed, by many, to Arrow (1963). The association of the origins of health economics to Arrow and not to Mushkin or Lees are likely due to several factors, which included the fact that Mushkin's (1958) article was published in the Public Health Reports, a relatively obscure periodical at this time, coupled with the fact that Lees (1961) makes no mention of uncertainty as an economic characteristic of health, something discussed by Arrow (1963) in great detail in his work.

In this context, health economics appears as a branch of economics, defining itself as the study of how limited healthcare resources ought to be used to meet our needs, leading to the adaptation, by health economists, of a very 'medical' model of health, where healthcare appears as an intermediate good without intrinsic value in itself but necessary in the production of health itself (Edwards, 2001). In the analysis of such definitions, we can deduce an essential distinction between two possible fields contained in Health Economics: healthcare and health as a standalone entity.

The first notion of Health Economics divided in two separate fields of research appears in Mushkin (1958) with the statement: "*The subject matter of health economics includes factors that determine price patterns for health services, ways in which the materials, goods...are brought together at the right time and place and in the right proportions to provide health services... The mechanisms by which goods and services are coordinated are "trade" in the market by the consumer's purchase of health goods... Health economics also includes in its subject matter the effects of health services on the size, character, and efficiency of the work force and population*" (pp. 791-792).

This distinction also appeared in Arrow (1963) with the evidence: "*It should be noted that the subject is the medical-care industry, not health*" (pp. 941). The same vision was shared by Grossman (1972a and 1972b) - according to him, we can see health as a

general concern and healthcare as just one of the inputs for health - (Fuchs, 2000; Maynard and Kanavos, 2000; Phelps, 1995; Williams, 1993). All these visions connected almost exclusively the discipline to healthcare, that is, they argued that the focus of health economics would be almost exclusively on the production, distribution and organization of healthcare. However, the concepts 'health economics' and 'healthcare economics' only began to be used distinctly from Edwards (2001).

Nowadays, this distinction is widely visible across research areas, as it is usual to see papers classified either health or as healthcare, disaggregated between research dedicated to the realm of health and the others solely focusing on healthcare (Cardoso, 2008). Thus, we are not stating that a complete schism exists between the two disciplines rather that the two do share some common components where knowledge can be shared.

In relation to public concerns, healthcare has been more predominant than health due to methodological and conceptual issues. The availability of data about healthcare and the existence of specific tools to deal with the data create an opportunity for research – studying demand for healthcare involves fewer risks than studying demand for health. Furthermore, the need for responses about health market failures and the role of public intervention to effectively provide healthcare for citizens constitutes yet another reason for the dominance of healthcare economics.

To this end, we can say that a market can exist for healthcare, but not for health, where healthcare appears as an input that is necessary to produce health, with others goods and social factors (Edwards, 2001). As we will see outline below, over time, the determinants of health have been dynamic and fluid, fluctuating in perceived significance over time.

One of the paramount factors responsible for achieving high levels of public health (social model) was a shift in overall habits by researchers, thanks in large part to the advances verified at the medical (Biomedical model) and technological (eHealth) level. Moreover, ICTs have also yielded an important impact over time in the healthcare sector, not only in maintaining cost efficient and high quality health and social care, but also in the

empowering people of every age to better manage their health and quality of life. Later sections will be given a special emphasis and focus on the impact of ICTs in the health sector.

2.3 ICTs: Their Development and Their Role in the Health Care Sector

The improvement in living conditions of the populations associated with the emergence of chronic illnesses resulting from the increase in longevity has changed people's overall attitude and perception towards healthcare. More and more people, instead of simply receiving treatments for their illness, began to give more importance to high quality preventive healthcare over time.

The existence of demanding and better-informed patients in terms of quality, associated with the need to control costs in the health sector, also led to the creation of a need to invest in processes/infrastructures that were able to increase the quality of care in a more efficient and effective way (improve productivity, efficiency and patient focus).

Historical data concerning the evolution of populations reveals that, after the second half of the twentieth century, the world witnessed a significant improvement in overall health status across populations, which was reflected in a significant reduction in mortality and progressive increases in longevity (World Health Organization, 2010).

The reasons behind these improvements are not consensual among academics and researchers, some of which argue that the improvement verified in populations' health status was achieved due to technical developments in medicine – the Biomedical model. Others, argue that such phenomenon were due to social advances verified in the living conditions of populations – social model of health (McKeown and Lowe, 1974).

The Biomedical model was a product of the seventeenth century that interpreted medicine as an activity closely linked to the exercise of professional power, due to the fact

that control over health and disease was increasingly practiced by health professionals in detriment of the people themselves. In this model, biological factors were only responsible for the health status of the patient, excluding any kind of psychological, environmental, political, and social factors.

Alternatively, the Social model emphasizes the role developed by factors such as better nutrition, personal hygiene, social and environmental background, sanitation, level of education and information, etc., relegated to the health status of the patient. The principles underlying this model are also more tangibly analyzed and seen, if only by the fact that the improvement of the population's health status has begun, roughly a century before the medicine has had effective means of fighting diseases.

The ideology underlying the Social model of health is also present in the definition of health by the World Health Organization (1948): "*Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*". To be considered a healthy individual, he or she needs to be well not only physically and psychologically but also being in balance with the environment that surrounds him, with no signs or symptoms of diseases.

According to the Social model, to be possible to obtain a high level of health, a connection between the health sector and all other sectors related to development is necessary. This process involves not only governments, through the implementation of healthy public policies (including reforms in the environmental area, slum clearance, improved sanitation, and clean air), but also all the overarching community (with changes in the individual behavior in health – family planning, accident prevention, weight control, alcohol consumption and smoking).

Simultaneously to advances across the health sector, living conditions of populations were also experiencing substantiated improvement. However, marginal gains derived from this improvement in the population health eventually reached a threshold, paving the way for technological innovation in healthcare as the main catalyst for development in the sector.

In addition to increases in life expectancy, the rise in the complexity of medical procedures and the emergence of new chronic diseases over time created a dilemma in the expenditures of countries' health systems, revealing the need to reduce costs in this sector. In essence, ensuring the sustainability of health systems and the growing demand for healthcare with more quality at affordable prices are were engrained as necessities, eventually pressing governments to effectively and efficiently manage the health sector, not only in qualitative and safety terms but also at the level of resources utilized.

The roots of modern health however can trace its origins back much further, having risen as a product of the Industrial Revolution, whereby developed countries started to invest in health technologies with the main goal of addressing the problems demonstrated by the sector (accessibility, quality and costs). This health industrialization allowed for the facilitation and emergence of new knowledge, procedures, and specific equipment to the area.

The first technologies had their main focus on the doctor and the disease, the patient being seen as something external to this relationship. Only later in time was a patient-oriented approach adopted (healthcare networks and electronic medical records, for example), which nowadays has evolved to a more focused approach on health and the citizen itself, with the fundamental aim of giving the patient a more active role in managing their health at home, or in their respective environment. However, due to the importance and weight that knowledge, information and communication have gradually acquired in the medical domain, some of the resources devoted to innovation have been focused in the ICTs, with the main objective of ensuring an effective and quick dissemination and switch of ideas.

ICTs is a generic term that includes any communication device or application, including computers and network hardware and software, cell phones, radio, television, satellite systems as well as the various services and applications associated with it, such as videoconferences. Although these technologies are present in different sectors, in this paper we will focus on ICTs in the context of health care, which is eHealth.

ICTs offer the integration of some already existing technologies, such as telephone or Internet services, into medical practice to help foster a significant difference in the access, efficiency, effectiveness and quality of clinical processes and in the patients' health condition. Nowadays, it is commonplace to see different personnel in the health sector using the internet for marketing purposes, not only to obtain medical information or consultation, but also to prescribe medicines, which reflects the influence exerted by the ICTs in the medical care provision.

In this sense, the current implementation of the ICTs across the health sector contributes to the mitigation of costs, coupled with increases in the quality of services provided. Moreover, the optimization of decision-making by health professionals and the reduction of medical errors offer a more economical approach to resource management (with the aim to control costs, as this sector is very important in terms of public expenditure). In any scenario, it has been observed that better training and the transmitting of knowledge amongst health workers through mechanisms such as e-learning can help fortify healthcare systems by upgrading the management of information and timely access to that information, including improved diagnoses and a modernized approach towards patient notes using wireless Personal Digital Assistants (PDA), among many other useful utilities.

Through these tools and advancements, it may be possible to improve the efficiency and safety in prescribing treatments and medicines using technology-based electronic prescriptions ("e-prescribing"), while also enhance clinical quality and the financial viability of the practice. In addition, the advent of technology has also led to higher quality medical services through improved channels of information and the reduction of duplicative documentation, which ultimately helps streamline the information exchange between providers internally and through different organizations, at both a regional and nationwide level, through a comprehensive network. Indeed, all organizations can benefit from greater efficiency measures and through the reduction of costs associated with providing services (European Commission, 2004).

This trend had not gone unnoticed and the European Commission in 2004 recognized the role of the new ICTs applied to health, namely eHealth, as an effective and efficient mean to overtake and respond to challenges in the health industry. eHealth encompasses all the ICTs tools and services for health used behind the scenes by healthcare professionals, or directly by patients, which help improve the health of citizenry on a global scale. Through the use of ICTs, responsible authorities also want to enhance healthcare quality and reduce healthcare costs, thereby improving the efficiency with which healthcare is delivered and reducing the delivery of services with little or no value (European Commission, 2004).

eHealth technologies appeared as the result of academic research concerned with imaging applications and laboratory automation. The successful use of the X-Ray (first used in 1895) for diagnostic purposes early in the twentieth century contributed/encouraged the introduction of new technology such as ultrasound (1942), and Magnetic Resonance Imaging (1973) to support diagnoses and the treatment of diseases. These are still considered new techniques, given that computed tomography scans, organ transplants, arthroscopic surgery, and selective serotonin reuptake inhibitors were uncommon or virtually unknown fifty years ago.

eHealth at its core is about modernizing health system methods and technologies to increase the quality, safety, timeliness and efficiency of health service, including all medical healthcare services and technologies that rely on modern information and communication technologies, which implies something more than the simply Internet-based applications. The efficiency in the provision of healthcare implies a creation of an effective integrated system of information's transmission in this sector. It is critical to ensure timely and accurate collection and exchange of health data, since the health sector is information intensive. Newer generations of ICTs are also able to promote transmission of information between the different channels in the health sector, which can reduce the operative and administrative cost through the monetary and timesavings on the patient information's process. This is reflective in the reduction in the number of documents on paper (electronic billing, for example). However, for this approach to be possible, it is necessary to create a

national and/or international easily accessible communication network, containing the most relevant information about patients.

Additionally, the use of the ICTs as a strategic tool in the promotion of safer, and more adequate healthcare enables industry professionals to spend more time with their patients and to adapt healthcare to individual needs using available resources more efficiently and effectively. eHealth also includes not only tools for health professionals but also for patients (personalized health systems), enabling the promotion of patient's autonomy (raise the involvement of patients and responsibility for their own health). This autonomy, associated with the development of a communication system that is capable of providing timely and specific information to the patients, can be a possible way to reduce costs in the sector. Thus, we may defer to ICTs in order to enhance patients' autonomy in managing their own health through the use of opportune and relevant information about their state of health.

Although the majority of the ICTs' promoters in health advocate for positive benefits originated from the implementation of such technologies in the health sector, a uniform international consensus about the potential benefits and savings of what can be achieved in the health sector unfortunately does not yet exist (Brailer, 2008; Chaudhry *et al*., 2006; Hill *et al*., 2007). This is because the controversy relegated to ICTs lies not only in the qualification of the benefits, but also in its quantification caused by the inexistence of a globally accepted form of measurement.

Regardless, the rapid development and integration of ICTs and their consequent effect on the health sector have necessitated the replacement of the such antiquated terms as 'medical informatics' (the processing of medical data by computers) and 'information processing; having presently evolved to 'information communication'. The common denominator of all these technologies is data digitization, which enables the processing and dissemination of patient data in the mode to which we have become accustomed. Through these advances, the use of the ICTs for data collection, analysis and modeling, ultimately yield a more important role than ever. Despite all the advantages associated with the introduction of the ICTs however (reduction in medical errors, improvement in health

efficiency, significant reduction in storage space and more share ability of medical information), currently, the use of these technologies in health sector still remains somewhat limited.

Despite the success of digitalization in other information intensive industries, the industry itself has not been as dynamic or open to change as much of the health data continues to be processed manually and X-ray images that are sent by regular mail. These techniques are certainly more expressive in diagnostics (computed tomography and magnetic resonance imaging, for example) than in process organization. A continued reliance on these means ultimately serves as a barrier that prevents greater proliferation of ICTs. In the next section, we will analyze in more detail the obstacles that the ICTs face.

2.4 The Limited Use of ICTs

Despite the fact that the field of health economics is built on pillars of knowledge and information, there is a technological lag in the implementation of ICTs compared with other similar industries with these same characteristics. The limited use of ICTs in the medical area is not something specific to electronic health records but an example of the limited use of ICTs in health care more generally. The health industry invests only about 2% of its revenues in Information Technologies compared with 10% of other information-intensive industries, indicating an under-exploited and under-appreciated use of ICTs in the health sector (The Economist, 2005). Such a situation is especially due to the existence of legal, operational, cultural, attitudinal, and financial barriers in the health sector to the implementation and use of such technologies.

On one hand, the existence of several laws with the aim of promoting privacy of patients can jeopardize the system, due to the tradeoff between privacy of patients and increasing interoperability between different service providers. Conversely, the absence of a law that simultaneously standardizes the procedures in the treatment of medical

information and clarifies the liability of providers in the disseminated information can also be a seen as a legal barrier in the adoption of the ICTs (Hill and Powell, 2009).

The operational barriers arise mainly in the absence of an electronic language and uniform procedures amongst service providers, which makes the improvement of internal processes and communication between them and between physicians and patients, very difficult (Hill *et al.*, 2007). The fact that, an individual who acquires the technology is not the same one that will use it creates space for the emergence of conflict situations around the adoption of the same by the clinicians. In this respect, the change of health professional's mentality, by the explicit demonstration of the benefits that arise from such adaptation to their own practice (reducing medical errors, less waste of time), helps improve efficiency, cost savings and greater access to information that the ICTs will provide. Moreover, these will help erode or eventually overcoming one of the main obstacles to the adoption of the ICTs. However, training health professionals to properly deal with new technologies is another challenge that must be faced.

The slow adoption of ICTs in the healthcare area is also due in large part to the bias of incentives to adopt the these technologies themselves, resulting from the fact that health sector is not inserted into a real competitive market, specifically as payment is respectively diffused between patient, employer and insure. This creates an enigmatic state in which the patient does not have a simplified conception of the costs involved in receiving medical care.

Sometimes, the incentives given to services providers are not the most appropriate in promoting the adoption of ICTs, aside from being frequently seen as a misalignment of incentives between those who must pay for eHealth and those who are the direct beneficiaries (Brailer, 2008). The indexation of health professional's payment to billable events (operations and medical consults, for example) creates a disincentive in the use of techniques that can reduce medical errors and secondary complications (Hill and Powell, 2009). Furthermore, the health sector is not included in a genuinely competitive market (a significant percentage of the institutions in medical care are nonprofitable institutions), which generates some inertia in the adoption and use of ICTs as a privileged mean to save

resources. If patients support all the costs of healthcare received, and assuming that economic agents are rational, patients would thereby require medical services with good quality at reasonable prices. Thus, medical care providers (hospitals, clinics and private doctors) would have more incentive to adopt cost-reducing technologies that would allow for the maximization of services' quality in order to become more competitive.

Avoiding the isolation of medical providers from the market forces can also possibly reduce the technological lag between medical sector and others information and communication-intensive sectors inserted in a competitive market, transforming ICTs adoption, which would succeed in lowering costs. The 'first-mover disadvantage' is another kind of problem that blocks the implementation of the ICTs. Presently, the first healthcare entity to adopt any kind of ICTs can only maximize the value of his investment when other entities adopt the same kind of technology – network Effects (a large majority of the ICTs exhibit network effects in the sense that give a utility to their users that increases with the number of other users of that technology). Only when ICTs' adoption reaches the 40-50% threshold of exposure will market forces take over because health ICTs will become a requirement for doing business (Brailer, 2008).

The high costs associated with the implementation of ICTs are also a barrier for the technology's diffusion. This logic can be traced back to a statement by Feldstein (1971): "*…new and sophisticated equipment has been a crucial factor in rising medical care outlays. New technology (automation) in medicine, unlike that in other industries, has unfortunately tended, on the whole, to be cost-rising rather than cost-saving. The initial expense for the new equipment and its installation is often high…Once the equipment is in place, operating costs, including the cost of the highly trained personnel usually required, can be substantial*" (Watson, 1977, pp. 4).

According to Cutler and McClellan (2001), the only way to understand such barriers involves the comprehension of the different forms in which technology affects the health system – the treatment substitution effect and the treatment expansion effect. Generally, new technologies are introduced in health sector with the aim to replace old technology previously used to treat certain conditions, i.e. the treatment substitution effect. In turn, the second effect is related with the possibility offered by the new technologies in the treatment

of a wider range of people that were not covered by the old technology. For example, cataract surgery was performed much more frequently as the procedure improved over time (Cutler and McClellan, 2001).

2.5 Managing the adoption of ICTs

From an economic point of view, the implementation of ICTs will also be advantageous if they simultaneously allow for the reduction in administrative and operative health services costs and allow the emergence of new delivery models of medical service, which help encourage the innovation and the generation of savings in resources). In economic terms, the implementation of ICTs in healthcare will be profitable if their benefits, as often measured by the Quality-Adjusted Life-Years (QALYs), outweigh a given level of costs. The QALY is a measure of the burden of disease, including both the quality and the quantity of life lived. It is based on the number of years of life that would be added by the intervention.

In order to assess whether the benefits from the implementation of new technologies in health outweigh the costs, Cutler and McClellan (2001) analyzed the introduction of ICTs in five specific conditions (heart attacks, low-birth weight infants, depression, cataracts, and breast cancer) concluding that, "*the estimated benefit of technological change is much greater than the cost*" (pp. 11) – such conclusions do yield profound implications for public policy undertaken in health area.

On a broader scale, some countries such as the United Kingdom and Australia, have founded institutions with the sole aim to economically evaluate the adoption of certain technologies (not only ICTs but also myriad drugs) in health. By this same vein, the National Institute for Health and Clinical Excellence (NICE) was created in United Kingdom and the Pharmaceutical Benefits Advisory Committee (PBAC) appeared in

Australia, both utilizing cost-effectiveness analysis as a mean to evaluate the possible implementations of the ICTs and drugs.

Created in 1999, the NICE is an independent health organization of the NHS in England and Wales, responsible for providing national guidance, based on cost effectiveness and efficacy analysis of the situations in question. Its guidance embraces clinical practice (in the evaluation of the most appropriate treatment, for example), the use of health technologies within the NHS (such as, in the use of new and existing medicines) and guidance for public sector employees on health, with the aim to promote good health and prevent and treat diseases.

The PBAC is an independent expert body appointed by the Australian Government, constituted by doctors, health professionals, health economists and consumer representatives. Its primary role is to recommend new medicines for listing on the Pharmaceutics Benefit Scheme. When recommending a medicine for listing, the PBAC takes into account the medical conditions for which the medicine was registered for use in Australia, its clinical effectiveness, safety and cost-effectiveness ("value for money") compared with other treatments.

In general terms, the creation of these entities was based especially in the pursuit of value for money in healthcare, given the largest issues in the health sector are understanding how governments can get more value for what is spent and how they can get a more competitive market for healthcare services. NICE has a range of responsibilities of which the best known are the guideline 'products', covering both guidance on the use of individual health technologies and clinical guidelines on medical conditions (Towse and Pritchard, 2002).

The cost-effectiveness analysis is the criteria used by this kind of institutions to guide the adoption of new and existing technologies. This analysis includes not only the total costs of implementation (both financial and in terms of resources) but also all cost savings that accrue through the adaptation. It is the privileged tool used to allocate scarce healthcare resources based on the costs and benefits of available medical technologies (Anupam and Philipson, 2007).

If a technology, after being created, has a low cost-effectiveness (static benefits do not outweigh the costs), it will not be implemented. According to Anupam and Philipson. (2007) "*technologies are most cost-effective when the associated consumer surplus – the benefits to consumers net of the price paid – is also large. Consumer surplus concerns the difference between benefits and costs, versus cost-effectiveness criteria, which concern the ratio*" (pp. 698).

Although recent studies (have confirmed that the implementation of ICTs in information intensive industries allows significant gains in data sharing with high levels of privacy and security, facilitating the information's organization does not preclude the existence of key barriers impeding a more widespread use of ICTs (Brailer, 2008; Khoumbati *et al.*, 2006; Miller *et al.*, 2005). Hence, the acceptance and the accessibility to the new technologies are essential to enhance the demand and use of new equipment and services available to the medical community. According to the World Health Organization (2006), the use of ICTs in the health sector not only refers to its technological aspect, but also to the means necessary to achieve certain results.

Despite the technological lag that has occurred in the health sector during the last years, the medical community has continued to undergo an increasing adoption of ICTs in the medical field. This phenomenon is due in part to the broader use of the Internet and browsers by patients with the aim of acquired medical information about their respective conditions. Such empowerment of patients, equipped with easily accessible information on health, disease prevention and disease management, has collectively led medical professionals to recognize ICTs' integral role in the delivery of reliable healthcare.

However, in order to verify the optimization in the use of new technologies with the aim of improve the delivery of healthcare, it will still be necessary to address a series of challenges in the future. According to Haux (2006), the creation of institutional health information system strategies will be required, at both the national and international levels, covering the all aspects of the health system. That is to say there remains a need to consolidate the legislation in this area and establish a close collaboration between health

professionals, public and private sectors, and government. This would effectively allow for the reduction of costs through the sharing of resources between institutions.

Moreover, the provision of worker-specific skills, in regards to utilizing ICTs, will be another possible challenge to be addressed in the future. It will be necessary to provide some skills and technical training in order to facilitate the use of ICTs and reduce the reticence demonstrated in the adaptation of such technologies in the sector. Alternatively, the diffusion of ICTs could also lead to problems of compatibility and interoperability between systems and technologies, which would imply the development of adequate infrastructures to resolve such technical challenges (Lèger, 2000). Regardless, proponents of ICTs are hopeful that greater volumes of personnel familiarized with eHealth services will correlate to an increased demand for these kinds of services. As such, in the future, it will also be necessary to invest in more infrastructures and equipment to ensure, not only a proper response to this growing demand (telemedicine, for example), but also to enable the cessation of information gaps and poor communication between medical personnel and institutions. Finally, the more intensive reliance on new technologies in the treatment of medical information will also require greater attention to security to ensure a higher level of patients' privacy and confidentiality.

It is important to note the effective limits potentially reaped through the adoption of new technologies – while ICTs are ultimately designed to provide better quality of life for patients, they are not enough by themselves to fully guarantee a truly effective assistance to the patient. Consider an example where the psychological state of a patient is worse than his physical state, requiring human care treatments that ICTs simply are not equipped for. The healthcare sector's should embrace a greater reliance on advanced technological resources due to its benefits, though nevertheless health specialists should be careful about the risk of mechanization of the healthcare, always mindful of the benefits of human contact.

2.6 Conclusion

Health economics is the coalescence of a global discipline, associated with the developments and progress observed in medicine in spite of a counterbalance of high costs associated with their practice that have instigated significant increases of health spending as a share of gross national product in developed countries (Barros, 2009). Since Mushkin's paper published in 1958, the literature about health economics issues has become far more widespread and embraced in the academic and economic community via countless scientific publications and tireless research. The evolution of the Health Economics has led to adopt a very 'medical' model of health, in which the predominant production input for health is health care (Edwards, 2001). In spite of the first notion of Health Economics division into two fields of research that has appeared in Mushkin (1958), Arrow (1963) and Grossman (1972 a and b)), only in 2001 the distinction between healthcare economics and health economics was public recognized with Edwards' paper (2001), a key precipice.

The wave of innovations verified in the health sector during the past few decades, such as the introduction and use of health technologies and the emergence of new drugs, and medical equipment, to name a few have created the need to invest in new processes/infrastructures. Moreover, these innovations collectively help increase the quality of care in a more efficient and effective way, including the implementation of techniques such as eHealth.

Despite the role played by eHealth in terms of economic efficiency and cost control the use of the ICTs in health sector still remains limited in several health areas, due to the existence of some barriers, inherent to the sector. Notwithstanding these issues, the study developed by Cutler and McClellan (2001) concluded that, in some specific conditions (as heart attacks, low-birth weight infants, depression and cataracts), "the estimated benefit of technological change is much greater than the cost".

As such, the future will aim to ensure the best use of ICTs in health sector, while also addressing the specific challenges such as the creation of institutional health

information system strategies and a national and/or international communication networks, the harmonization of the healthcare legislation, the provision of specific skills to the health workers, and finally the enhancement of the compatibility and interoperability between systems and technologies, among others.

Chapter 3

3. What are the Drivers of the Overall Increase in Healthcare Expenditures? A new Look at Technological Innovation*

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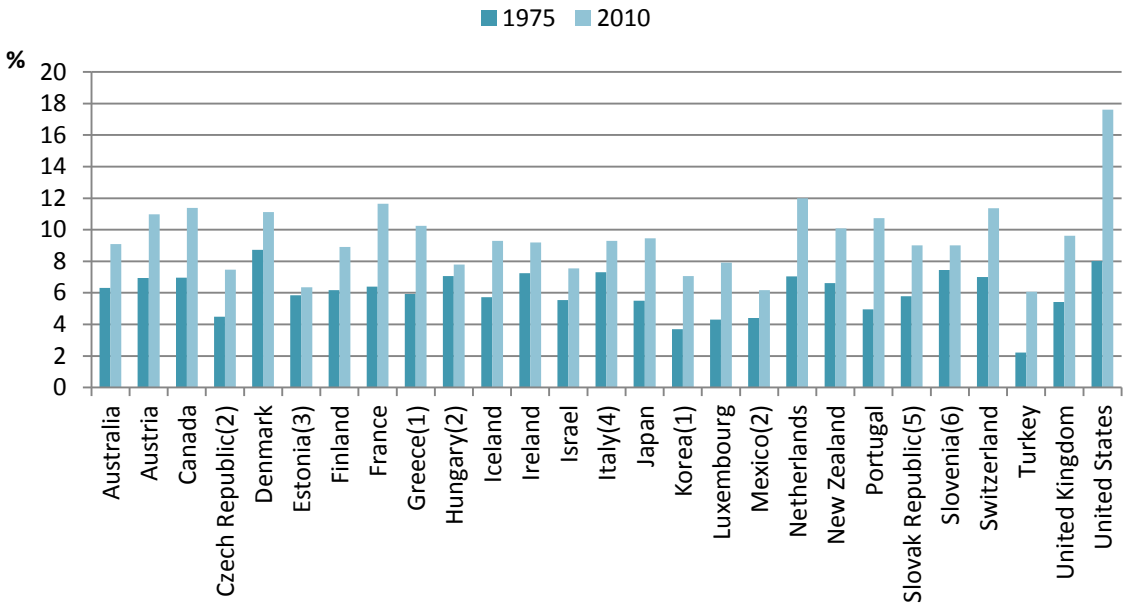
3.1 Introduction

Over time, the period of rampant growth in healthcare spending attracted the attention of several leading health economists, organizations, and policymakers, whose chief concerns were to address issues related to healthcare expenditure's cost-containment and cost-effectiveness. Indeed, within just two decades, the impact of health on Gross Domestic Product (GDP) effectively doubled across countries, which raised a series questions about the reasons and sustainability of such growth. For example, between 1960 and 1980 the weight of healthcare spending in GDP in Iceland, Ireland, Japan, Norway, Spain and USA increased from 3%, 3.7%, 3%, 2.9%, 1.5%, 5.1% to 6.4%, 8.2%, 6.4%, 7%, 5.3%, 9%, respectively (OECD Health Data, 2012).

With an aim to combat the increasing pressure exerted by the mounting trend of healthcare expenditure against national budgets, some countries, namely in the OECD, had moved to adopt a number of healthcare reforms, such as the introduction of prospective payment systems and top-down budget controls, downsizing in the hospital sector and decreasing the number of healthcare personnel, the combination of cost-containment strategies with long-term structural changes to improve value-for-money in healthcare, the shift of healthcare expenditures to private financing; strategies to control utilization, the imposition of budget constraints on providers, requiring individuals to bear a greater share of their expenditures, through an increase in copayments; demand and supply-side cost sharing, the separation of the role of supplier and buyer, the alignment of incentives with objectives through contracts, the decentralization of decisions, the limitation of budget transferences, the control of prices and wages, among others (Docteur and Oxley, 2003; Imai, 2002; Oxley and MacFarlan, 1994).

However, despite the implementation of such reforms, presently we continue to observe a significant growth trend in healthcare expenditure, not only in relative terms but also in absolute terms, as shown in Figure 3.1.

Figure 3.1. Health Expenditure as a share of GDP



In this figure we compare healthcare expenditure as a share of GDP in 1975 and 2010, in different OECD countries, using OECD Health Data (OECD, 2011). As it is possible to see, the percentage of healthcare expenditure as a share of GDP increased from 1975 to 2010. 1: 1980; 2: 1990; 3: 1999; 4: 1988; 1997; 6: 1995.

Notwithstanding this recent trend, real growth in healthcare expenditure *per capita* began in the 1950s, coinciding with a period of economic expansion and social progress across developed countries. This process led to the implementation of social reforms in order to ensure more benefits to workers, specifically broadening their respective access to healthcare. Moreover, other factors seem to have contributed to the increase in healthcare costs, including demographic factors, the re-organization of healthcare system, and technological and scientific progress, among others.

Amidst this context, some studies started to appear in the 1970s that catalogued the analysis and consequent influence exerted by certain measurable variables, such as inflation, ageing, medical visits, and number of beds, on healthcare spending (Klarman *et al.*, 1970). By the 1990s, an expansion of the literature had widened to the contemplation of effects of certain behavioral variables and other non-directly measurable variables – some studies used the theory of growth accounting and the residual approach to indirectly

measure one of the most intriguing paradoxes witnessed across health spending, i.e. the impact of technological innovation on healthcare costs (Newhouse, 1992; Peden and Freeland, 1998).

In spite of the importance of these works, their utilized methodologies underscore certain shortcomings, namely that there is a compound risk of confounding technological innovation in health with other factors that are not fully captured by the regression, cautioning against the final interpretation of the results.

To allay these prior concerns, the purpose of this paper is to determine the main factors that, over the last few decades, have contributed to the increase in healthcare spending, explicitly focusing on the impact of technological innovation in the healthcare sector. Relying on multiple imputation techniques in order to overcome the problem of missing data, we add to this literature by using a panel data analysis, which we are aware, has only been used by Gerdtham *et al.* (1998) and McGuire *et al*. (1993). Moreover, we will augment the existing literature by directly analyzing the impact of technological innovation through the creation of a healthcare technological composite index that are able to reflect the role of new technologies in healthcare sector.

According to our results, ascertained by the composite technological index, we find that technological innovation has yielded a positive impact on total healthcare expenditures *per capita*. This suggests that the introduction of new technologies contributes to the increase in healthcare expenditures observed during the last few years, which is consistent with the results in the literature. Moreover, by analyzing the non-linear effects of cost increases, we can also conclude that this rise in healthcare expenditure *per capita* that is driven by technological innovation exhibits diminishing returns, eroding with volume. In addition, based on the results of our study, we were able to find that most of our sample of presently developed countries has passed a key inflection point, allowing them to

efficiently save resources with technological innovation[1]. This is a new result in the existing literature.

3.2 Literature Review

> *"I believe the bulk of the residual increase [in rising health care costs] is attributable to technological change, or what might loosely be called the march of science and the increased capabilities of medicine."*
>
> Newhouse (1992, pp. 11)

Real growth in healthcare expenditures *per capita* is not a recent phenomenon. This long-term trend began as early as the 1950s, coinciding with a period of robust economic expansion and social progress across a cascade of developed countries as well as the implementation of social reforms that ensured healthcare benefits to workers.

Over the years, other factors seemed to have contributed to this increase, including: technological and scientific progress, demographic factors such as the increase of population size and average life expectancy, the increase in female labor-market participation, the increase in the number and the price of medical procedures and staff, higher consumption of new drugs, the increase in health insurance or health system coverage and the re-organization of health care systems (reimbursement system, contract system, or integrated systems).

[1] In this paper, the concept of efficiency translates the maximization of population health status given the minimum amount of resources; both in terms of money, time, materials, and medical staff.

In the reimbursement system, providers receive retroactive payments for services supplied. The contract system involves an agreement between third-party payers (insurers) and healthcare providers, with the goal to have greater control over total funding and its distribution. On the other hand, in integrated systems the same agency controls both the funding and the provision of health services (Gerdtham and Jönsson, 2000).

Despite the verified slowdown in the share of GDP accounted for health in the 1980s, quite possibly as a result of reforms implemented especially in the 1960s by different countries, the growth of healthcare spending continues to be a recurring problem in the developed world to this day. Explaining the steady upward spiral of healthcare expenditures has been a popular and pressing theme on government researchers' agendas for several decades.

Aiming at understanding and restricting such growth, 1960s witnessed the appearance of the first studies of the different factors driving the growth of health spending.. The earliest studies performed to address this topic were done by Abel-Smith (1967), Feldstein (1971), Freeland and Schendler (1983), Fuchs (1972), and by Klarman *et al*. (1970), primarily based in the analysis of the influence exerted by certain measurable variables, i.e. inflation, ageing, medical visits, number of beds, in healthcare spending, not considering the observed effect of behavioral variables. These include for example, expectations and supplier induced demand, which theoretically affect the demand for health services, and consequently the level of healthcare spending.

The consideration of immeasurable variables only appears with the emergence of some more recent works done by Barros (1998), Cutler (1995), Newhouse (1992), and Okunade and Murthy (2002). These studies distinguished themselves by the fact that they made attempts to disaggregate healthcare spending growth, not only directly through measurable variables, but also through variables that allow translating the impact of behavioral factors in the demand of healthcare and the inclusion of phenomena that is not directly measurable, such as technological innovation. In this way, they factored in the estimates of some variables that were representative of all important behavioral factors.

Despite the prevailing literature that studies the determinants of healthcare cost growth utilizing different methodologies to analyze this same problem in question, these studies do share some conclusions that have been consistently pointed to the drivers that are deemed the most important. For example, authors agree that the effect of income on health expenditure is both positive and significant – an aging population plays only a minor role in increasing costs, the existence of 'gatekeepers' helps to reduce costs despite been usually insignificant, public sector provision of healthcare services increases health expenditure, and technological change is the most important driver of spending increases over time (Gerdtham and Jönsson, 2000).

To understand these conclusions in greater detail, in the next sections we will separately analyze the most important variables/factors, i.e. economic, demographic, social, behavioral and institutional variables that are present in the recent literature about the theme.

3.2.1. Aging

Population ageing is a sign of economic and social progress, however in developed countries this can also be a sign of increase in healthcare spending. According to Reinhardt (2003), people aged older than 75 years have a higher probability of requiring medical attention, incurring medical costs nearly five times higher in comparison with people aged 25 to 34 years. Or, according to Oxley and MacFarlan (1994) "persons aged over 65 consume, on average, roughly four times as much healthcare as those below 65". As such, as the healthcare spending generally increase with age and people live longer, it is natural to conclude that healthcare spending consequently grows with the aging of population. The increase in the proportion of elderly people in the population tends to increase the demand for health services, with the others things constant (Fuchs, 1972). This vision is defended especially by cross-sectional studies.

Even though some econometric studies have found jointly positive and significant influences of aging on healthcare costs (Blomqvist and Carter, 1997; Breyer and Felder,

2006; Hitiris and Posnett, 1992; Jönsson and Eckerlund, 2003; Lubitz *et al*., 1995; Roos *et al*., 1987; Schulz *et al*, 2004; Seshamini and Gray, 2004a, 2004b), there are still others that estimate a residual influence with insignificant results (Barros, 1998; Gerdtham *et al*., 1992a, 1992b and 1998; Gerdtham and Jönsson, 2000; Hogan *et al*. 2001; Hoover *et al*. 2002; Leu, 1986; Lubitz and Riley, 1993; Oxley and MacFarlan, 1994; Spillman and Lubitz, 2000; Stearn and Norton, 2004; Zweifel *et al*., 1999).

For example, Hitiris and Posnett (1992) found a positive and significant effect of age – they estimated an elasticity of health spending with respect to the share of population above 65 years old around 0.55, using for that the data from 20 OECD countries during an interval from 1960 to 1987. Blomqvist and Carter (1997) and Jönsson and Eckerlund (2003) arrive to the same conclusion. However, this work presented by Blomqvist and Carter (1997) was criticized due to the reduced number of explanatory variables used in the study, which may have skewed the results.

Looking closer at the analysis done by Gerdtham *et al.* (1992 a, 1992 b, 1998), it is possible to verify consistent results regarding the effects of aging on the growth rate of healthcare spending, even when the databases used are not congruent. For example, in Gerdtham *et al*. (1992b) the authors estimated an elasticity of only about 0.2 using the data from 19 OECD countries for seven-year intervals from 1980 to 1994. In a 1998 paper, Gerdtham *et al.* augmented the number of countries to 22 as well as extending the time period from 1970 to 1991. Under these alternative parameters, aging did not yield any effect on spending.

Under an alternative study, estimating growth rates rather absolute levels of healthcare expenditure using a sample of 24 OECD countries between 1960 and 1990, Barros (1998) concluded that aging was not a significant factor in the growth of healthcare spending. Additionally, Oxley and MacFarlan (1994) estimated a contribution of 0.2 percent *per* year to healthcare spending in 1980 – others estimations suggest a value of 2 percent for the expenditure incurred between 1940 and 1990 (Cutler, 1995; Newhouse, 1992; Smith *et al*., 2000).

Accordingly with some recent studies about the determinants of healthcare expenditure, the effects of population age structure in healthcare spending are usually insignificant, i.e. less than 0.7 percentage point *per* year, inconclusively explaining much of the increase in healthcare costs over time (Ginsburg, 2008). For Banins (2003), aging increases spending on health until a certain age level whereby its effect subsequently decreases.

As we see, the estimated value depends largely on the period under analysis and the others variables used. However, independently of the period in question, the contribution of the aging population to the growth in healthcare spending is much lower than is commonly perceived.

Some studies defend that it is not age per se that enhances the increase in healthcare spending rather the proximity of death in one's respective environment (Breyer and Felder, 2006; Brockman, 2002; Felder *et al*. 2000; Hogan *et al*. 2001; Hoover *et al*., 2002; Levinsky *et al.*, 2001; Lubitz and Riley, 1993; Lubitz *et al*. 1995; Mcgrail *et al*. 2000, Moïse and Jacobzone, 2003; Roos *et al*., 1987; Schulz *et al*., 2004; Serup-Hansen *et al*., 2002; Seshamani and Gray, 2004a, b; Spillmann and Lubitz, 2000; Stearn and Norton 2004; Zweifel *et al.* 1999). Under this logic it is this phenomenon that determines the positive relationship between spending on health and aging, given that increased proximity to death augments the probability of becoming ill – a state where medical care is at its highest. It is important to note that this finding is more common in longitudinal studies.

Despite the possible predisposition of an ageing population to incur higher levels of healthcare spending, according to the majority of studies, there are several others factors that play an even more important role in driving up healthcare spending. Furthermore, the implications of population projections should be treated cautiously due to the fact that the impact of aging on spending will depend, amongst other things, the intensive utilization of healthcare services, forms of elderly care and technology (Oxley and MacFarlan, 1994).

3.2.2. Income

During the last few decades, real income *per capita* has significantly risen, as well as the demand for healthcare itself. Acute or widespread rises in income can also change the patterns of overall consumption, depending on the type of the good, keeping everything else constant. There are two categories of goods when we compare its demand towards changes in income: normal and inferior goods. In the case of normal goods, with an increase of income, the demand quantity of such goods increases. Moreover, these goods can be further divided into so-called essential goods or luxury goods. In the latter case, the demand quantity increases at a rate higher than the increase of income (income elasticity is greater than one), while in the case of essential goods demand remains almost unchanged, and the income elasticity is greater than zero but less than one. In turn, regarding inferior goods, the demand quantity decreases towards increases in income.

Given the fact that healthcare is a seemingly desired service and generally accepted that the demand for healthcare increases with household's income, there are not as of yet a uniform consensus about the possible elasticity or inelasticity of demand for healthcare with respect to income (the income elasticity of demand allows evaluating the percentage change in demand for healthcare as a result of a percent increase in household's income). This happens because most studies developed on the topic use, as *proxy* of household's income, the value of GDP, which can lead to estimation errors on the income elasticity of healthcare since this proxy doesn't allow the isolation of household demand effects that are solely income-related. Estimated elasticity's with respect to GDP can also reflect both the political process and institutional arrangements (Oxley and MacFarlan, 1994).

Generally speaking, the use of GDP as an income variable relies on time-series analysis and international cross-section data, which often over-estimates the impact of income effects – in these cases, the elasticity is greater than one (Oxley and MacFarlan, 1994). For example Gerdtham *et al.* (1992a) estimated a GDP elasticity of 1.33, significantly above one. There are other studies that arrive to the same conclusion, that is, healthcare expenditure increases proportionally more than GDP: Gerdtham *et al*. (1998); Kleiman (1974), Leu (1986); and Newhouse (1977). In turn, Okunade *et al*. (2004)

obtained a GDP elasticity of healthcare expenditure of around 0.6, underscoring the fact that healthcare is a necessity rather than a luxury (Di Matteo, 2003; Freeman, 2003; Ginsburg 2008; Tosetti and Moscone, 2007).

Indeed, the problem of under or over-estimation in the elasticity of healthcare spending with respect to income is also prevalent whether this estimation is done based on micro (households expenditure) or on macro data, respectively (Docteur and Oxley, 2003). Morevoer, the elasticity based in micro data (for example, from the analysis in the variation across individual households) tends to be between 0.2 and 0.4[2] (Andersen and Benham, 1970; Grossman, 1972 b); Muurinen, 1982; Newhouse and Phelps, 1974; Okunade, 1985; Manning *et al*., 1987; and Wagstaff, 1986), being equal or greater than one (Getzen, 2000; Newhouse, 1977; Leu, 1986) using aggregate data (such as, national time series or cross sections of countries).

In a 1977 study, Newhouse tried to identify the factors that determine the quantity of health-care services. In this article, he compared healthcare expenditure and GDP *per capita* at exchange rates, concluding that GDP was the paramount determinant of healthcare expenditure and that the income elasticity of healthcare exceeds one, indicating that healthcare is indeed a luxury good. According to data collected in 13 developed countries in 1971, Newhouse concluded that aggregate income explains 92 percent of the variance on the level of healthcare expenditure *per capita* between countries.

Despite the criticisms pointed out by Parkin *et al*. (1987), most empirical research has confirmed the conclusions obtained by Newhouse's analysis (for example, the work developed by: Barros, 1998; Blomqvist and Carter, 1997; Culyer, 1988 and 1989; Gerdtham *et al*., 1992a and 1998; and Leu, 1986). Alternatively, a majority of studies suggested that this elasticity is less than one (Oxley and MacFarlan, 1994) estimating an income elasticity of 0.7-0.8), while a smaller number of studies have argued that it is above one. If it is in fact true that the demand for healthcare increases substantially in the same

[2] A 10 percent increase in income increases health spending by between 2 and 4 percent. This estimated low elasticity may reflect the fact that generally, people with better health have higher incomes while those who need more healthcare are those with less income.

proportion as income, we cannot a priori expect that the increase in health spending is mostly due to rising incomes.

Moreover, income elasticity of healthcare demand depends on other factors beyond the variation in income, such as the existence of insurance, the healthcare system, and the institutional environment, among others. For example, aesthetic surgery, physiotherapy, or more comfortable surroundings (private rooms) may be more sensitive to income. However, there is no net effect on the influence of these factors in the final value of elasticity, such that their role is often ignored (Oxley and MacFarlan, 1994).

3.2.3. Insurance Expansion

An overall growth in the number of insured individuals can lead to an increase in healthcare demand, because with insurance patients do not bear the full cost in the use of medical services, consequently facing a net decrease in the net price of care. This phenomenon happens since, according to a basic law of economics, when a given price of a good falls, the demand quantity increases, holding for the case of a normal good. An increase in "total insurance cover" is equivalent to a reduction in the price of medical care to the individual consumer at the moment of its delivery. Assessing the impact that this might have had on overall spending is difficult because there are few estimates of the price elasticity of demand (Oxley and MacFarlan, 1994).

However, this trend can be seen when we analyze the behavior of the expenditure of other health services where insurance plays a minor role than in hospital services. For example, in dental services, the expenditure has risen much less rapidly over time than the expenditures in hospitals or on medical doctors (Fuchs, 1972). A notable example of this is the Rand Health Insurance Experiment, a randomized experimental study of the impact of insurance coverage on health spending and its decomposition at the household level, which estimates the sensitivity to the price paid out-of-pocket for healthcare is between -0.1 and -0.2, indicating that the expansion of health insurance only contributes marginally to health spending growth (Manning *et al*., 1987).

In a Congressional Budget Office (CBO) study (2008), the expansion of insurance coverage verified between 1940 and 1990 contributed to 10% to 13% to the growth in healthcare spending during this period. Alternatively, others studies such as Aaron (1991), Manning *et al.* (1987), and Newhouse (1993), estimate a percentage between 5% and 10% from 1950 to 1984.

Ultimately, despite the fact that health insurance is not an integral driver of spending trends, it can in fact exude its influence on delivered care – this is seen in the provider's productivity and the introduction of new technologies in the health sector, which in turn can exert pressure on healthcare expenditure growth (Ginsburg, 2008).

3.2.4. Physician-Induced Demand and 'Defensive Medicine'

Since the industry's inception in developed countries, access to healthcare services is largely controlled by doctors and other healthcare professionals due to the sector's own rules and the existence of asymmetric information between patients and medical employees. In the health sector, doctors play a crucial role in this relationship given their decisions and that their behaviors affect all other interactions in the sector. When the workload decreases, doctors can use such power in order to induce more demand for their services at higher prices – supplier-induced demand. According to Newhouse (1992) and Smith *et al*. (2000), the increased expense that comes from the desire of doctors in maintaining or increasing their income by inducing demand for their services is not important enough to singularly explain the increase in health spending during the last decades – further conclusions are also convoluted given the difficulty in verifying and measuring such phenomenon.

In capturing the influence of this phenomenon across total healthcare expenditure growth, there are some studies that use the number of physicians per 1.000 population (Gerdtham *et al*., 1998 and Okunade *et al*., 2004), while others opt for a sample of number of physicians per 100 hospital beds (Christiansen *et al*., 2006), or the number of practicing physicians *per capita* multiplied by 1.000 (Gerdtham *et al*., 1992a). The results obtained

from these studies are contradictory between them. If on the one side, Christiansen *et al*., (2006), and Gerdtham *et al*. (1998), find a negative effect, whereas on the other side, Okunade *et al*. (2004) find a positive effect. Gerdtham *et al*. (1998) find a positive effect when they combine the supply of doctors with a fee-for-service system.

Despite this disparity, sometimes physicians prescribe certain exams or procedures, with few or no benefits for the patients, instead focusing on the overt prevention against possible future liabilities, which is denoted by defensive medicine. According to Reynolds *et al*. (1987), such behavior could be responsible for 1% of all medical expenditures in 1984.

3.2.5. Prescription Drugs and the Pharmaceutical Industry

The Pharmaceutical industry emerges as another dark horse factor behind the rising cost in health sector despite sometimes being categorized in the technology category. This industry can be seen as one of the world's most research-intensive sector, verifying, in the last four decades, a quadruple increase in the average cost of its innovations, which has contributed in part for the rising costs in the health sector (Kumar and Ozdamar, 2004). For example, in 1993 the weight of the pharmaceutical sector on total healthcare spending was 8.3 percent in the USA, 15.4 percent in France, 18.5 percent in Germany, and approximately 29 percent in Japan (Scherer, 2000).

Despite the fact that prescription drugs probably do contribute to the reduction of health expenditure through the replacement of certain medical procedures such as surgeries (for example the case of anti-ulcer drugs), the weight of the pharmaceutical sector relative to the total healthcare spending and the total pharmaceutical sales per capita has increased over time, representing an important and growing share of health expenditures in across most countries (Huber and Orosz, 2003). According to the OECD (2003), in the 1990s, the annual growth rate of pharmaceutical expenditure was 30 percent higher than that of total healthcare expenditures.

According to Mehrotra *et al*. (2003), this anomaly can be explained through the fact that, over the years, pharmaceuticals companies have raised the prices of certain drugs, effectively increasing in the number of people relying on drugs due to the emergence of new diseases. Moreover, drug advertising is a powerful tool, which creates an artificial demand that can be guilty of leading people to consume more drugs, also opting for the replacement of older drugs by newer and more expensive ones.

3.2.6. 'Gatekeepers'

The gatekeepers of primary care are generalist doctors that establish the first point of contact between the patient and the healthcare system, cornering in this way the access between a hospital and specialist care. The existence of gatekeepers is more important in situations where there is an over-supply of physicians, checked by strong competition among physicians for market shares and remuneration on a fee-for-service basis (Gerdtham and Jönsson, 2000).

Most the studies that include the use of primary care "gatekeepers" in the regression estimated coefficients that suggest lower levels of health expenditure in the presence of gatekeepers. For example, according with the estimation done by Gertham and Jönsson (2000), the countries with gatekeeper register healthcare spending 18% lower than countries without such entities. In turn, Christiansen *et al*., (2006) found a positive relation between gatekeeper and healthcare expenditures, whereas Barros (1998) concluded that the variable gatekeeper yielded an insignificant role in the control of healthcare costs.

3.2.7. Technological Change

The concept of health technology not only involves medical devices (e.g.: magnetic resonance imaging and computed tomography scanner, coronary artery bypass graft, etc.), but also advanced equipment's used in medicine such as new procedures, processes and techniques, i.e. electronic medical records and transmission of information, telemedicine.

As such, technological changes involve not only new equipment's and procedures but also improvements in existing equipment. As mentioned above, there have been copious studies that include pharmaceutical goods in this category, which will not be the case in this paper.

According to Cutler and McClellan (2001), technological change in healthcare affects the system in two ways: through treatment substitution effect and treatment expansion effect. Generally, new technologies are introduced across the health sector in order to replace outdated technology that was previously used to treat certain conditions – tabbed the treatment substitution effect. In turn, the treatment expansion effect is related to the possibility offered by new technologies of the treatment of a wider range of people that were not covered by the old technologies themselves. For example, cataract surgery was performed much more frequently as the procedure improved over time.

Unfortunately, these effects can also lead to an increase in healthcare costs given new technologies are typically more expensive and their introduction increases the type and the number of treated patients. Even if new procedures are less expensive than traditional ones, the increase in the intensity of their use can override the possible cost savings. This is the case of cataract surgery and the treatment for depression with selective serotonin reuptake inhibitors, which have cut costs but, at the same time, expanded the number of treated patients (Ginsburg, 2008).

Furthermore, since these technologies are often rapidly and broadly widespread, it can reduce the utilization rate, consequently increasing the cost per treated patient, and in some cases can even be used on people for whom the benefits are smaller (Methrona *et al*., 2003). Even in circumstances when technological innovation allows the use of cheaper medical technologies, the increase in the range of possible treatments promotes the increase in demand and supply (Weisbrod, 1991). For example, the new procedures that have emerged for the treatment of heart attacks and breast cancer are two kinds of technological changes that have increased spending via treatment substitution effect (Ginsburg, 2008).

Moreover, technological progress makes it possible to avoid the death of some patients by curing certain pathologies that were previously fatal (at this point could also be discussed the additional burden brought by these people at the social security system). In

this way, over time, technological innovation may have also indirectly contributed to the growth of healthcare spending by increasing the survival rate, which also increases the number of chronically ill people. Indeed, these individuals can induce more costs to the health system because, as it is expected, they will need more healthcare services than the rest of the population or they will have more severe diseases, something that would have not occurred if they had died (Moïse, 2003). In this way, some technological advances in healthcare didn't arise to as a means of preventing or curing diseases, rather to keep people alive, albeit at huge costs, which is the case of organ transplant, radiotherapy and chemotherapy (Kumar and Ozdamar, 2004). Additionally, according to Cutler (1995), even if new technologies or drugs are cost saving, there are other reasons that complicate the saving or conservation of resources. For example, certain preventive care can be given to everyone in the population, not only the people infected with certain disease. In some cases, depending on the number of people who become ill, a broad based application of a new technology may be preferred to prevent the spreading of a disease.

While technological innovation in healthcare focusing especially on its importance in the cost increase, we cannot neglect its capabilities in the possible cost savings through the improvement in the overall quality, timeliness, safety and efficiency of healthcare service provided. For example, according to Hillestad *et al*. (2005), the use of electronic health records (a record in digital format that contains current and historical patient information) could produce efficiency and safety savings of $142 billion in U.S. physician offices and $371 billion in U.S. hospitals over the next fifteen years.

As such, evaluating the impact of technological progress in healthcare costs is a necessary and complicated task due to the difficulties that arise from the direct measurement of aggregate technological change in the sector and the difficulty in obtaining a measurable proxy for technology.

Even with these difficulties, recently several studies have emerged trying to measure the role of technological innovation in healthcare expenditure growth. Among them we can highlight the work done by Barros (1998), Cutler (1995), Newhouse (1992), and Okunade and Murthy (2002). Cutler (1995) and Newhouse (1992) tried to disaggregate

health costs growth, not only directly through measurable variables, but also through variables that translate the impact of behavioral factors in the demand of healthcare and the inclusion of phenomena that are not directly measurable. These studies include such measures and effects as technological innovation, revealing a common conclusion – technological innovation is one of the most important determinants of health expenditure growth.

"*Rapid scientific advance always raises expenditures, even as it lowers prices. Those who think otherwise need only turn their historical eyes to automobiles, airplanes, television, and computers. In each case, massive technological advance drove down the price of services, but total outlays soared*" (Aaron, 2002, pp W85).

Newhouse (1992) uses the theory of economic growth, more properly the Solow model, to analyze the determinants of health expenditures in the United States of America (USA) in the post-war period – 1950 to 1980. In this sense, he builds a regression composed of variables that are capable of representing some factors known as sources of expenditure on health, i.e., aging, the spread of insurance, income growth, supplier-induced demand (number of physician), and the productivity growth in medical care. Using a residual approach, post-estimation, he concludes that the main force behind the growth in health expenditures between 1950 and 1980, was the emergence of new medical technologies and services and their respective adoption (the omitted variable in the regression). According to Newhouse (1992), technological change contributed roughly by half of the verified increase in healthcare expenditures, such that the others factors taken together only explain the remaining 50%, at most.

Peden and Freeland (1998) utilized the same approach, operating under the assumption that low coinsurance levels and high research spending induce technological progress. With this specification, they concluded that roughly 70% and 76% of the health spending growth in the USA, as verified between 1960-1993 and 1983-1993 respectively, was due to cost-increasing advances in medical technology. However, it is necessary to stress that the methodology used by Newhouse (1992) and Peden and Freeland (1998) exhibits some tangible shortcomings with regards to the residual approach, given there is a

risk of confounding technological innovation in health with other factors for which the contribution is not fully captured (as for example education, lifestyle and environment questions) by the other variables included in the regression, demanding some care in the final interpretation of the results.

Despite this methodological limitation, Newhouse's work (1992) gained significance and importance in the area, not only for being the first one to assign a central role to the new technologies in determining the growth of healthcare spending, but for being the first to use the theory of growth to explain such phenomenon, which had facilitated the adoption of the idea among economists (Cutler and McClellan, 2001; Okunade and Murthy, 2002; Moïse, 2003). The first economists to attribute an important role to technology in the determination of health expenditure growth were: Aaron (1991), Feldstein (1971), Fuchs (1972), Goddeeris (1984 a and b), Manning *et al*. (1987), and Weisbrod (1991) (Moïse, 2003).

A small number of studies, relying on methods other than estimating a residual, instead use proxies for technological innovation in health to measure the impact of technological innovation in healthcare costs. For example Cutler and McClellan (1996) use treatment for heart attack as a proxy for technological innovation because they have been subject to constant technological improvements over the last years. Their findings corroborate Newhouse's (1992) conclusions that technology is a large determinate to cost growth. In 2001, they expand their work to treatments for low-birth weight babies, depression, cataracts and breast cancer.

Okunade and Murthy (2002) seek to validate the conclusions obtained by Newhouse (1992). In order to do that, in the analysis of health spending growth verified in USA between 1960 and 1997, they use total Research and Development (R&D) spending and R&D spending specific to healthcare as *proxies* for technological change in health. According to the authors, such variables reflect the technological progress in health by the fact that the probability of technological innovation in the sector increases with these variables. The obtained results, this is, the elasticity of total R&D spending and R&D spending specific to healthcare with respect to health spending growth was 0.3 and 0.4

respectively, confirm that the technological innovation in the sector is an important factor in the justification of the long-term growth in healthcare spending.

Other works have being made in the area, include a focus on specific medical equipment (Baker and Wheeler, 1998), surgical procedures (Weil, 1995), using as *proxy* for healthcare technology a time index variable (Gerdtham and Lothgren, 2000), or a time trend (Matteo, 2005). The estimation obtained by Matteo (2005) allows concluding that 62% the increase in health expenditure is due technological change in the sector.

According to Jönsson and Eckerlund (2003), technology is not the cause of the increased spending on health but rather a consequence of such increase. In turn, Newhouse (1992) argues "*I believe the bulk of the residual increase is attributable to technological change, or what might loosely be called the march of science and the increased capabilities of medicine*" (Newhouse, 1992, pp. 11). This explanation has received growing attention throughout the last decade amongst health economists, including notables such as Fuchs (1996), Okunade and Murthy (2002), and Cutler (2004).

Invariably, we can ask ourselves why the economies continue to invest in developing technologies that supposedly contribute to increase spending on health. Furthermore, it bears understanding why expensive health technologies do not need to be used just because they are invented given the fact that the existence of a technology does not necessarily imply its use. Before being able to answer any question that may arise here, it is necessary to remember that there are many forces and pressures in the health market, not only from insurers, those also exerted from patients and health professionals (Hall and Charles, 2007).

The above factors aren't mutually exclusive – for example, income growth, patients' expectations and the expansion of health insurance can encourage the development of more expensive new medical technologies (Peden and Freeland, 1998), as a result of commercial interests by the pharmaceutical sector or by companies and medical device makers. "*With insured patients bearing little of the cost of new technologies and providers free to pass on these costs to insurers, the result was dramatic diffusion of new*

technology and substantial incentives to invest in cost increasing technologies" (Cutler, 1995 pp. 2).

With the purpose of determining the different relationships and impacts of these factors on overall healthcare spending over recent decades there have emerged different econometric papers and methods devoted to understanding this relationship. This paper aims to be included in this group, which seeks to differentiate itself from the others especially through the use of a complete panel database method, supported by multiple imputation (MI) and through the construction of a composite technological index able to reflect the role of new technologies in healthcare sector. In the next sections we will describe such methodologies and characteristics.

3.3 Methodology

This paper aims to examine the effects of different variables on the amount of healthcare expenditure *per capita* – to accomplish this we created an unbalanced database for OECD countries during the period from 1975-2010. The database is unbalanced in that we do not have variables for all countries for all of the years (see Section 3.4. below for details). Furthermore, despite careful data collection, some variables were not available in their entirety for all countries. Hence, we considered it appropriate to apply a methodology recently developed that deals with missing data, i.e. multiple imputation. In order to allow the familiarization of the reader to such method we will expose below a brief explanation of the same.

3.3.1. Multiple Imputation

The presence of missing values, i.e. missing data for some observations, is a recurring problem in any dynamic real-world investigation, which can potentially

compromise the conclusions if the researcher does not properly take into account this fact. This is due in large part because most of current statistics software were developed assuming the existence of complete databases and were excluded from the analysis observations with missing values – listwise deletion (Rubin, 1987; Allison, 2000).

Until the 1980s, most statisticians refused to work with databases containing missing values, seeing these datasets as something "*to be gotten rid of*" (Schafer and Olsen, 1998, pp. 4). However, over time there has been a pantheon of developments or techniques (imputation, likelihood, and weighting approaches) and software capable of compensating for this problem, which has facilitated the adaptation and the work of researchers managing such data (Horton and Kleinman, 2007). Turning to the methodology, it is critical in understanding a background rational for, how to deal with missing values as it is necessary to decipher the latent process of absent missing values, i.e., if the missing values are missing at random (MAR), completely at random (MCAR) or Missing Not at Random (MNAR) and the pattern of missing values, monotonic or non-monotonic.

A variable Y is "*missing at random (MAR) if the probability of missing data on Y is unrelated to the value of Y, after controlling for other variables in the analysis*" and is "*missing completely at random (MCAR) if the probability of missing data on Y is unrelated to the value of Y itself or to the values of any other variables in the data set*" (Allison, 2000, pp. 3-4). In addition, the Missing Not at Random (MNAR) missing values are all the other cases that are neither MAR nor MCAR, but nevertheless are systematic, that is to say the missing values depend on the values themselves.

Alternatively, "*data set is said to have a monotone missing pattern when the event that a variable Y_i is missing for the individual i implies that all subsequent variables Y_k, $k > j$, are all missing for the individual i*" (Yuan, 2000, pp.2).

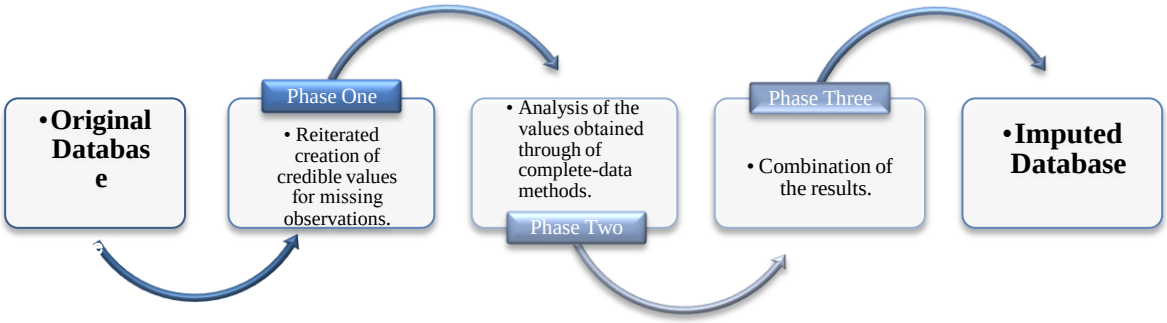
There are two generic approaches for dealing with missing data: listwise deletion and imputation of missing data. The latter varies through different complexities of methodologies from the simplest (simple imputation) to the most sophisticated (multiple imputation).

Listwise deletion restricts the analysis only to the complete observations, which ignores a great deal of potentially usable data. Despite this drawback, listwise deletion usually produces accurate estimates of the true standard errors and can be used in any database, irrespective of any specific computational techniques. However, it can also lead to larger standard errors, wider confidence intervals, and mitigated effectiveness in testing one's hypotheses. Moreover, the imputation approach sees the missing values as an integrate part of the database, trying to impute them with values by single methods – single imputation (mean/ median/mode substitution, regression imputation, expectation-maximization imputation, etc.), or multiple methods, and multiple imputation (e.g. Markov Chain Monte Carlo algorithm).

Single imputation consists of replacing the missing observation for a single value using one of many different methods, including: replacement by an estimate that characterizes the sample (simple average (Haitovsky, 1968; Schafer, 1999), the median of the missing variable (Edwards *et al.*, 2001) or conditional mean imputation (Little and Rubin, 1989); hot deck; regression (Khuri *et al.*, 1997); maximum likelihood estimate; among others. This method, like listwise deletion has an inherent disadvantage of creating standard errors that are underestimated and test statistics that are overestimated, underestimating the variability of the sample because any missing value is filled only once.

In order to overcome the problems of simple imputation, Rubin (1977 and 1987) subsequently Schafer (1997) and Allison (2000) developed a new method of imputation that seeks to deal with missing data using multivariate analysis – multiple imputation (MI). Through specific iterative algorithms, several imputations (N, with $N \geq 2$) are created for each missing observation (from the predictive distribution of the missing data), which, in accordance with certain assumptions, can produce valid statistical inference (Clark and Altman, 2003; Clogg *et al.*, 1991; Little, 1992).

Figure 3.2. Multiple Imputation process



This figure represents the three sequential phases of the multiple imputation process.

As we can see in the Figure 3.2, MI involves three distinct sequential phases according to Rubin (1976.) First, there is an iterated generation of numbers for missing values based on techniques that reflect the variability between imputations. According to tests performed by Rubin (1987) and Van Buuren *et al.* (1999), the optimal number of iterations to obtain valid inference is between 3 and 5. From this step, N new 'complete' datasets are created and will be separately analyzed in the second phase through standard complete data methods, resulting from these estimates, standard errors, and *p-values* that formally incorporate missing data uncertainty.

Finally, in the third phase, the results obtained in phase two are grouped in order to be analyzed and to produce valid statistical inference according to Rubin's theory (Rubin, 1987; Rubin and Schenker, 1991).

Suppose that we have imputed m complete datasets using an appropriate model. The combined estimate of each parameter is obtained according to the formula: $\bar{\beta} = \frac{1}{m}\sum_{j=1}^{m} \hat{\beta}_j$. The valid standard error for each estimate requires the combination of information on within-imputation and between-imputation variation. This is, the total variance is: $T = \bar{U} + \left(1 + \frac{1}{m}\right) B$, where $\bar{U} = \frac{1}{m}\sum_{j=1}^{m} U_j$ (Variance within the imputations) and $B = \frac{1}{m-1}\sum_{j=1}^{m}(\hat{\beta}_j - \bar{\beta})^2$ (Variance between the imputations) (Rubin, 1987 and Rubin and Schenker, 1991).

The punctual estimates of parameters are obtained by the average of multiple imputations and standard errors are obtained through the variance of multiple imputations. The N created databases are subsequently analyzed using the procedures that are used in complete data analysis. After the creation of a 'complete' database, it is possible rely on the use of statistical software programming that is able to handle missing values, such as SAS, STATA, Amelia II, Hmisc, S-Plus, among others, obtaining a set of final estimates and standard errors. Since this method uses an iterative process in order to impute a given value, the estimated standard errors are more credible than those obtained by simple imputation, allowing for more adequate statistical inference, thereby improving the estimates as well as the standard errors and test statistics and increasing efficiency of the estimates due to the minimization of such errors (Rubin, 1987).

Before the use of MI, it is necessary to justify or confirm if some assumptions are verified, especially as this method is functional under specific conditions. As such, the database should be MAR (which has been confirmed through the analysis of missing data patterns). Next, the imputation model must match the model used for analysis, whereas the dependent variable must also be included in the imputation model. Finally, the used algorithm must accommodate the necessary variables and their associations (Allison, 2000; Schafer, 1997).

Despite the noted potential advantages of these aforementioned methods, there also exist a series of shortcomings or disadvantages, such as the underestimation of the variability of the imputed variable, which will generate confidence intervals narrower than expected, and the impossibility of taking into account the variability. Besides this, some of the disadvantages mentioned by Rubin (1987) comparing simple imputation and MI (more effort to create multiple imputations, more time to run the analysis, and more computer storage space for the imputation-created datasets) have been overcome due to the current development of computer software capable of implementing such techniques.

During the last few years, several studies have appeared in order to test the validity of the MI (Ambler *et al*., 2007; Arnold and Kronmal, 2003; Moons *et al*., 2006; Shrive *et al*., 2006; Van Buuren *et al*., 1999; Van der Heijeden *et al*., 2006; Zhou *et al.*, 2001). Most

of these studies concluded that MI could indeed be efficient, since the obtained estimates for the imputed dataset are very similar to the obtained estimates for the complete database. In most of the created scenarios, MI was the best method for dealing with missing values. It is based on these studies that we decided to use the MI to deal with missing values, more specifically the Monte Carlo method based on Markov Chain (MCMC). This method aims to simulate multivariate distribution sets whose boundary is a stationary Markov chain that has the distribution that we want to find (Gilks *et al*., 1996). Moreover, the number of imputations was chosen following the recommendations by Graham *et al*. (2007). After dealing with missing values, it then becomes possible to carry out the construction of the composite technological index. The composition and construction of this index will be explained in the next section.

3.3.2. Technological Composite Index

The use of a composite technological index is proposed to address three issues: the lack of quantitative data able to reflect the technological level of the countries in the healthcare sector; the need to create a variable that could reflect such technological level, and the analysis of a composite indicator developed by the United Nations – the Technology Achievement Index (TAI). The United Nations Development Programme developed the TAI Index and presented for the first time in the Human Development Report 2001, *Making New Technologies Work for Human Development*. This index aims to measure the technological achievements of a country in four dimensions: creation of technology, diffusion of recent innovations, diffusion of old innovations and development of human skill base for technological creation and adoption.

The variables used in the construction of the technological composite index present in this paper, have been collected from the OECD database, according to the available data. The methodology behind the construction of such variable was based on the work of Nardo *et al*. (2005), in which the weights of different variables were computed using factor analysis. Factor analysis aggregates indicators that are collinear with the aim to form a

composite indicator capable of capturing as much of common information of those variables as possible. The first step involves the creation of the factor loadings matrix through the Principal-component factor. Next the matrix is rotate and the weights are calculated (Nardo *et al*., 2005).

In Annex A, Table A.4, we list the variables that constitute the present index with their respective weights. This index has two main groups of variables: group one (MRI, PET, GAMMA, DSA, MAM, RTE, LITH and MRIE) corresponds to healthcare machinery available in the country, while group two (END, DIA, FUKIDNEY, BONE, HEART, LIVER, LUNG and KIDNEY) represents the most innovative medical procedures of the past few years. By incorporating these two groups we want to replicate, such as in the technological composite index, the treatment substitution effect, and the treatment expansion effect presented by Cutler and McClellan (2001). The selected technologies were collected taking into account the year in which they appeared and were used.

3.4 Data Collection

The basic statistics presented in this paper have mainly been compiled from different OECD sources and from the World Bank. The unbalanced dataset covers 27 OECD countries, some of them between the years 1975 to 2010 – the descriptive statistics of the variables are in Table A.3 in Annex A. The set of countries in the sample is constituted by Australia (1975-2008), Austria (1975-2009), Canada (1975-2010), Czech Republic (1991-2009), Denmark (1975-2009), Estonia (2000-2009), Finland (1975-2010), France (1976-2009), Greece (1981-2007), Hungary (1992-2009), Iceland (1975-2010), Ireland (1975-2009), Israel (1995-2009), Italy (1989-2010), Japan (1975-2008), Korea (1981-2010), Luxembourg (1996-2009), Mexico (1991-2010), Netherlands (1975-2009), New Zealand (1975-2009), Portugal (1975-2008), Slovak Republic (1998-2009), Slovenia (1996-2009), Switzerland (1975-2010), Turkey (1976-2008), United Kingdom (1975-2009), and the USA (1975-2009). The dependent variable used is the log of total health expenditure *per capita* in US dollars, converted at economy-wide Purchasing Power Parity (PPP) – $THEX_{pc}$.

In order to reflect some common factors among the countries that justify the cross-country and cross-time differences in aggregate expenditure, we use as explanatory variables some socio-demographic variables: Gross Domestic Product *per capita* in US dollars, converted at economy-wide PPP (GDP_{pc}), the proportion of population 14 years and under (POP14), the proportion of population over the average life expectancy (EMV), life expectancy at birth (LEX), the number of infant mortality, deaths per 1.000 live births (IM), the proportion of urban population (URB), and the unemployment rate (UNEMP).

Alcohol consumption in liters *per capita* (ALCOOL) and the proportion of population aged 15 and over who are daily smokers (SMOK) were included in the model to add lifestyle factors that show how individual health affects spending in ways not directly through health care spending (McKeown, 1979; Mokyr, 1997). We also introduce some institutional variables as out-of-pocket health expenditure, % of private expenditure on health (OUTP), the total pharmaceutical sales *per capita* in US dollars, converted at

economy-wide PPP (PHARM), and health expenditure financed by General Government, % of GDP (GOV). Finally we use our technological composite index (INDEX). The multiple regression analysis is present below and it is constituted by some of early-defined determinants and by others considered important for the explanation of the growth of healthcare spending in the last years.

The model of aggregate healthcare expenditure *per capita* of the *ith* OECD country in year *t* is obtained:

$$\mathbf{THEXpc_{it}} = \boldsymbol{\beta_0} + \sum_{\mathbf{n=1}}^{\mathbf{11}} \boldsymbol{\beta_n} \mathbf{X_{nit}} + \boldsymbol{\beta_{12}} \mathbf{INDEX_{it}} + \boldsymbol{\beta_{13}} \mathbf{INDEX_{it}^2} + \sum_{\mathbf{i}}^{\mathbf{27}} \boldsymbol{\mu_i} \mathbf{d_i} + \sum_{\mathbf{t}}^{\mathbf{35}} \boldsymbol{\vartheta_t} \mathbf{d_t} + \mathbf{e_{it}}.$$

$$\boldsymbol{X} = \{\boldsymbol{GDP}, \boldsymbol{POP14}, \boldsymbol{EMV}, \boldsymbol{URB}, \boldsymbol{ALCOOL}, \boldsymbol{SMOK}, \boldsymbol{OUTP}, \boldsymbol{IM}, \boldsymbol{PHARM}, \boldsymbol{GOV}, \boldsymbol{UNEMP}\}^{3}$$

As it can be seen from the expression above, the 27 (35) d_i (d_t) are dummy variables with the value 1 for each of the 27 (35) observations corresponding to country (time), in order to control for any factors that are fixed within each country (and time period). These include two way fixed-effects models and β_0 as an overall constant as well as a 'country effect' for each country and a 'time effect' for each period.

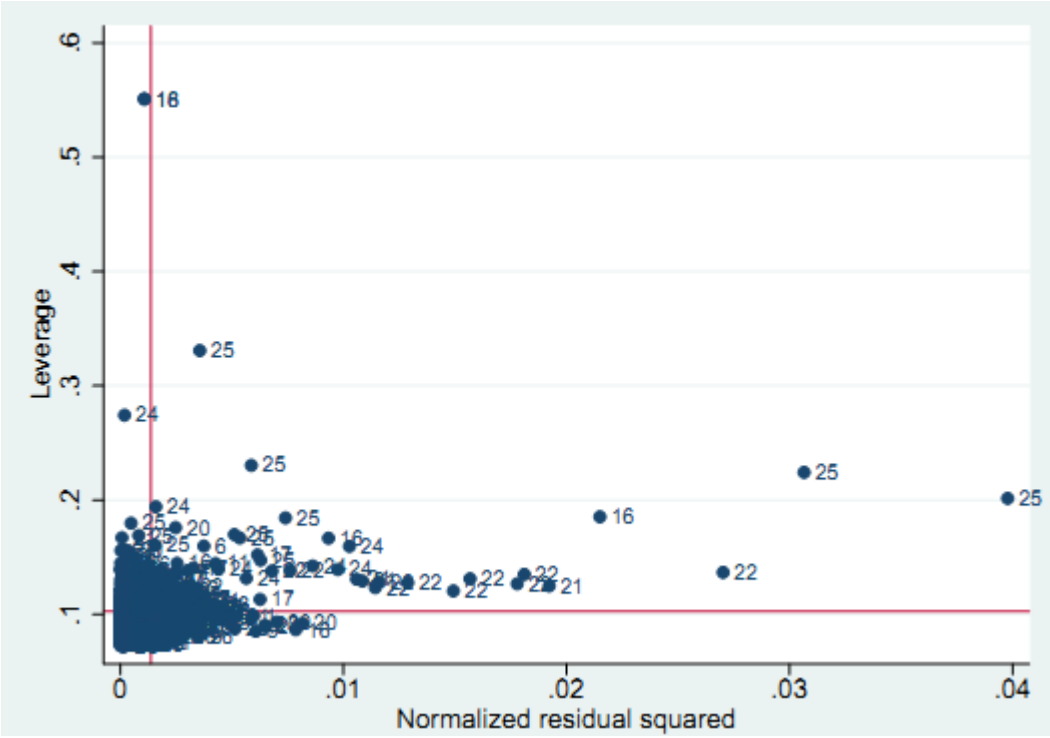
The independent variables in the regression, except the variable INDEX, are in log form, so the coefficients associated with these variables represent the long-term effects of such variables on health expenditure. For example, it is estimated that an increase of 1% in X_1 will increase health expenditure *per capita* by $\hat{\beta}_1$%, *ceteris paribus*. In addition, the regression model was estimated using STATA with robust regression as the estimation technique (Huber, 1964). Despite the fact that Ordinary Least Square (OLS), or other methods of regression, have favorable properties in comparison with robust regression, the use of robust regression aims to overcome some limitations of traditional parametric and

[3] The definitions of the variables are in Annex A, Table A.3

non-parametric methods, allowing amongst other things, the mitigation of the effects of possible outliers and the preservation of the order, dispersion and symmetry of the dataset.

In this sense, we decided to use robust regression due to the identification of outliers in the dataset (as we can see in the Figure 3.3, where the countries Korea (16), Slovak Republic (22) and Turkey (25) have either high leverage or large residual), through the use of classical regression diagnostics techniques adapted to imputed data, and due to the existence of a strong suspicion of heteroskedasticity in the data.

Figure 3.3. Leverage versus the normalized residual squared for the countries in the sample



Note: This figure was created from the dataset used in this paper to analyze the existence of outliers. It is possible to see that Korea (16), the Slovak Republic (22) and Turkey (25) are possible outliers in that they have either high leverage or a large residual.

3.5 Results

The regression results are presented in Table 3.1– there are certain variables that yield a significant impact on health spending across the different regressions. This is the case for GDP_{pc}, POP14, EMV, URB, ALCOOL, OUTP, IM, PHARM, GOV, UNEMP, INDEX, and INDEXSQ. Moreover, the determinants of health expenditure those are included in the regression account for almost all the variability of health expenditure *per capita* across a range of different specifications, as shown by the high estimated R^2.

Table 3.1. Estimated coefficients of Fixed Effects Models (FEM) for the log of healthcare expenditure *per capita*

Variables/Models	1	2	Number of observations pre-imputation	Percentage of imputation
GDP *per capita*	0.822[a]	0.826[a]	754	-
Proportion of population with 14 years and under	0.134[a]	0.130[a]	754	-
Proportion of population over the average life expectancy	0.016[b]	0.014[b]	731	3%
Urban population	-0.256[b]	-0.286[a]	746	1%
Alcohol consumption	0.05[a]	0.050[a]	754	-
Tobacco consumption	0.001	0.013	377	50%
Out-of-pocket health expenditure	-0.051[a]	-0.046[a]	400	47%
Infant mortality	-0.096[a]	-0.117[a]	754	-
Total pharmaceutical sales *per capita*	0.015[c]	-	377	50%
Health expenditure financed by Government	0.647[a]	0.644[a]	732	2.9%
Unemployment rate	-0.012[b]	-0.008	754	-
INDEX	0.405[a]	-	249	67%
INDEXSQ	-0.534[a]	-	249	67%
Constant	-0.544	-0.513	-	-
INDPHARM	-	0.769[a]	249	67%
INDPHARMSQ	-	-0.683[a]	249	67%
R^2	0.8167	0.8148	-	-
F-statistic	1973.88	2310.85	-	-
F-test	0.000	0.000	-	-
F-test against 1 - FEM, C	119.65[a]	164.01[a]	-	-
F-test against 1 - FEM, T	3.05[a]	3.12[a]	-	-
F-test against 0 - FEM	73.93[a]	75.94[a]	-	-

Note: Models 1 and 2 regress healthcare spending per capita on different factors, including a technological composite index, using fixed effects for country and time period (fixed effects were not included in the table). In model 2, the technological composite index is enhanced to include pharmaceutical spending. a, b, c represent 1%, 5% and 10% levels of significance.

Through the statistical analysis (*F*-statistic and *F*-test) it is possible conclude that the model is statistically significant (we reject the null hypothesis that all the slopes equal zero). The larger the *F*-statistic, the more useful is the model. This is also corroborated by the high value of the R^2, which means that approximately 80% of the variance of the log of healthcare expenditure *per capita* is accounted for by the model. We found that the best fit for the data was a model in which fixed effects were used both for countries and time compared to when we used fixed effects for just time (F-test against 1-FEM, T), for just countries (F-test against 1-FEM, C), or when we did not use fixed effects (F-test against 0-FEM). All the test results are statistically significant, which supports the decision of using 2-way fixed effects models, for country and time.

Income elasticity is lower than one (0.82), whilst also highly significant in all regressions and positive as expected, reflecting the fact that healthcare is a necessity rather than a luxury. These results are consistent with other studies including Barros, 1998; Di Matteo, 2003; Freeman, 2003; Ginsburg 2008; Tosetti and Moscone, 2007. Furthermore, the variable POP14 is positive and also significant in all regressions. The sign of this coefficient is consistent with theory that assumes that children between 0 and 14 years of age need more healthcare services than the rest of population.

With the aim of measuring the impact of aging on total healthcare expenditure we created a variable that captures the ratio of people over average life expectancy for each country – EMV. According to our estimation, when the number of adults above the average life expectancy increases by 10%, we expect an increase of 0.17 percentage points in healthcare expenditure. The amount of private expenditure on health (OUTP) contributes to a decrease in health spending. This is consistent because the increase in the percentage of private expenditure on health represents an increase in the health price paid by the agents, which leads them to demand less healthcare services, contributing to the reduction of such expenditures. This result can also be associated with some adaptations to a reduction in insured people.

The results obtained ultimately support both a significant and positive relationship between GOV and health expenditure. In particular, this result is consistent with the

emphasis of current governments on reducing the share of healthcare expenditures that are publicly financed because there is a contagion effect between the two variables. The higher the percentage of healthcare expenditure financed by the government, the higher the expenditure (so it will be necessary to finance an even larger amount of health expenditure, which will compromise more and more the solvency of public accounts).

According to our results, there also exists a significant and negative relationship between infant mortality and health spending *per capita*. As such, when infant mortality decreases, health care spending increases. We also estimate the impact of the pharmaceutical industry through the prescription of drugs on total health expenditure, which has not been measured in related papers. The results suggest that the pharmaceutical sector has a positive impact on health-care costs, which supports the theoretical results of Kumar and Ozdamar (2004).

We include URB and UNEMP to estimate $THEX_{pc}$, but we find significant results opposite to what is expected. Although unexpected, the results obtained in these variables are quite consistent with the analyses elaborated by Gerdtham *et al*. (1992a, 1992b, 1998) that find a negative effect of urbanization on healthcare expenditure, and by Christiansen *et al*. (2006) that also find a negative effect of unemployment on total healthcare expenditure *per capita*.

Relatively to the variable URB we find that urbanization has a negative effect on healthcare expenditure, which is difficult to explain because according to some studies (Kleiman, 1974) it is expected that the increase in the urbanization rate leads to an increase in healthcare costs due to the higher risk of contagion and lower time travel costs in urban areas. Some possible explanations may arise from the fact that in urban areas there is widespread access to improved water sources and improved sanitation facilities. These improve personal hygiene and consequently the quality of urban life and decrease the emergence of certain diseases. Moreover, a larger proportion of people with high education in urban areas lead to a greater awareness of positive health behaviors, through nutrition, diet, or exercise, for example. These collectively improve the health status of the population, which can lead to a lower need of healthcare services.

The negative effect on healthcare expenditures was obtained in the variable UNEMP, which was also unexpected due to the positive link that is established between unemployment and bad health (Christiansen *et al*., 2006). However, if we assume that unemployed people are exposed to less risk (work accidents/injuries, for example), while simultaneously avoiding stressful working situations, we can conclude that the increase in the unemployment rate leads to a decrease in the demand for healthcare. Apart from this, with more free time, people can apply a part of that time to take better care of themselves. This hypothesis is defended by Ruhm (2000, 2003 and 2005) who argues that unemployed people have more time for leisure healthier habits. Finally, we find that the composite technological index (INDEX) has a positive impact on total healthcare expenditure *per capita*. This implies that new technologies contribute to the increase in health expenditure verified in the last years, which is in line with the results obtained by Newhouse (1992), among others.

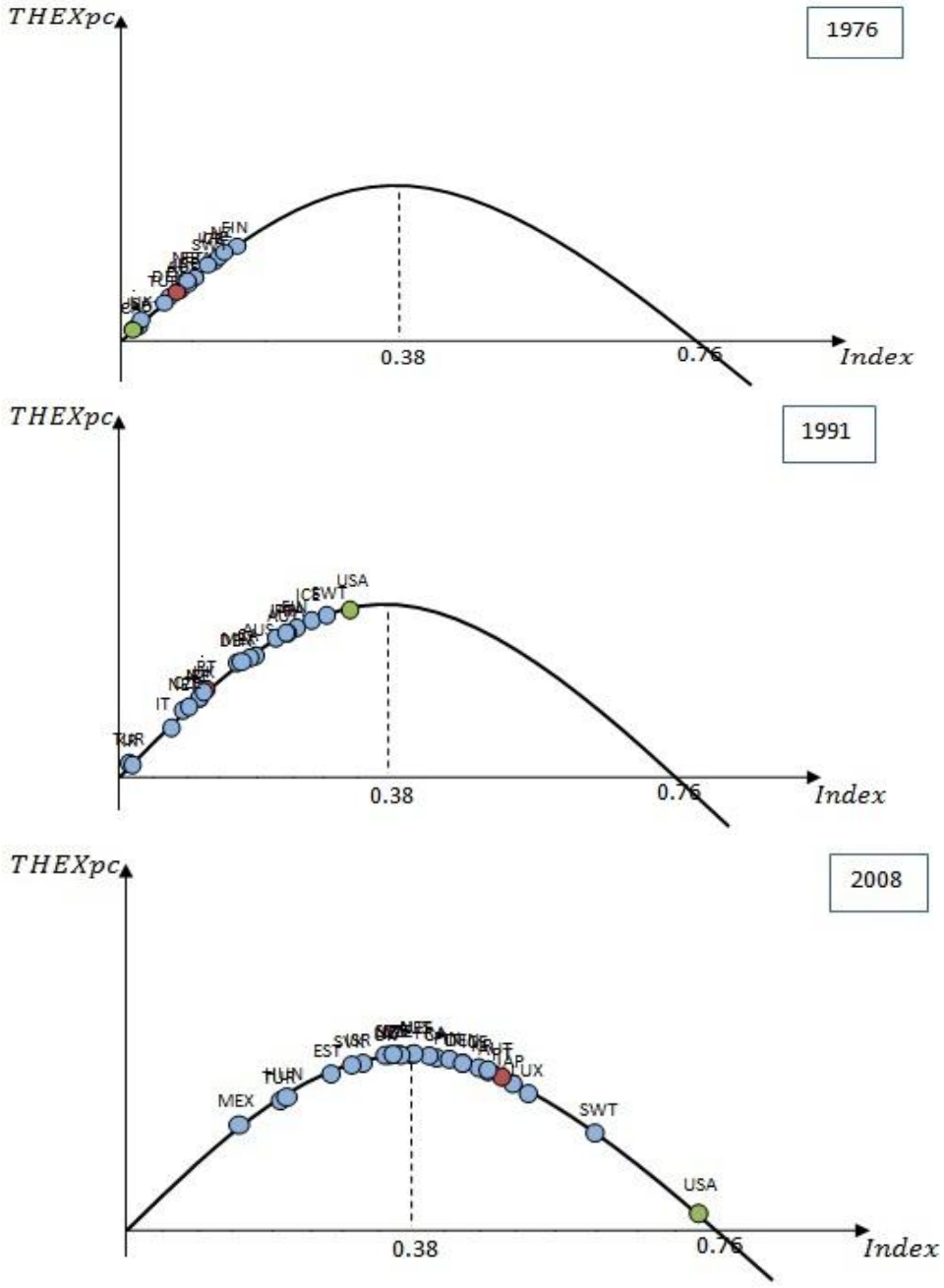
To allow for non-linear effects of the index on health care expenditure, we included a variable for the index squared (INDEXSQ). However, based on the coefficient for this index squared, we can conclude that this increase in healthcare expenditure *per capita* has diminishing returns. More interesting, when we compare these results with the actual healthcare technological position of each country, we can argue that most of the developed countries nowadays are beyond the 'turning point', whereby the weight of innovation on healthcare costs becomes increasingly lower through diminishing returns.

These patterns can be seen in Figure 3.4. In the first and second graphs corresponding to the year 1976 and 1991, all the countries in the sample are in the first phase. In this scenario, an increase in technological innovation will lead to an increase in healthcare costs. In the third graph however, we can verify that, most of the countries in the sample (Australia, Austria, Canada, Denmark, France, Finland, Iceland, Italy, Japan, Korea, Luxembourg, Netherland, Portugal, Switzerland, and USA) are on the right side of the turning point. This suggests that an increase in innovation will lead to efficiency gains that allow for a reduction in the contribution of technology to total healthcare costs.

Despite the initial effort of required investment, additional investments are offset from efficiency gains through the use of technology. This fact may lead to an increase in global divergence between countries with respect to technological level in the healthcare sector, given that countries with a lower technological levels in healthcare (Czech Republic, Estonia, Greece, Hungary, Ireland, Israel, Mexico, New Zealand, Slovak Republic, Slovenia, Turkey, and UK.) do not benefit from the resource savings that countries with a higher technological level benefit from, making them more prone to invest in technological innovation. This fact may also be aggravated by the weak capacity of the countries with a lower technological capacity to invest in more technologies due to the initial costs that it entails.

When the variable PHARM is integrated in the technological composite index, the conclusions about the impact of technological innovation in healthcare spending remain unchanged. However in this situation, it is verified that the number of countries on the right side of the turning point – in the third phase – are higher than in the previous situation (Figure A.5 in Annex A). In other words, we find that when we account for pharmaceutical spending, the weight of innovation on healthcare costs become increasingly lower for more countries. This may happen because the access to drugs it is easier than the access to new medical equipment, this is, the use of drugs involves a lower investment by the countries.

Figure 3.4. Contribution of technological innovation to healthcare costs



Note: These graphs were created from the database used in this paper and each of them shows the relationship between healthcare expenditure per capita and the variable INDEX, over three years (1976, 1991 and 2008), for the countries in the sample. According to these charts, the increase in healthcare expenditure per capita exhibits diminished returns fading away with its volume. In 2008, most of the countries were beyond the 'turning point' (0.38), where the weight of innovation on healthcare costs becomes increasingly lower.

Other variables were tested, such as the total number of hospital beds per million population, the number of doctors' consultations *per capita*, the number of hospitals *per* million population, the number of professionally active physicians *per* million population, and the number of total health employment *per* million population. However, these variables were not statistical significant, which led to their exclusion from the analysis. Meanwhile, the study of possible time breaks in the period in question was also considered, however these results did not suggest the existence of any time breaks. Such conclusions might be due to the fact that the variables present in the regression already were captured endogenously, or rather because there is not any significant time break over the period considered.

3.6 The Validity of Multiple Imputation

To test the validity of Multiple Imputation (MI) we compared the main model with a model that does not use multiple imputation. It is important to mention that when we use multiple imputation we are unable to calculate the technological composite index because the proportion of missing values for the variables that constitute the index is too high, and hence we do not have enough observations to construct the technological composite index. After running the regression without using MI and without the introduction of the technological composite index, we find that most of the explanatory variables are statistically insignificant (Table 3.2). One likely reason for this is that the number of observations is lower than the number of observations when we use MI; with MI we have 754 observations whereas we have 377 observations without using MI. A second possible reason is that we have taken out the technological index, which we believe is important for the model.

Table 3.2. Estimated coefficients of the Fixed Effects Model (FEM) for the log of healthcare expenditure *per capita*, without the use of Multiple Imputation

Variables	Coefficients	Number of observations
GDP *per capita*	1.08[a]	754
Proportion of population with 14 years and under	-0.29	754
Proportion of population over the average life expectancy	0.01	731
Urban population	-0.11	746
Alcohol consumption	0.06	754
Tobacco consumption	0.01	377
Out-of-pocket health expenditure	-0.23	400
Infant mortality	0.06	754
Total pharmaceutical sales *per capita*	-0.03	377
Health expenditure financed by Government	0.91[a]	732
Unemployment rate	-0.01	754
Constant	-3.85	-

Note: In this model, we regress the log of healthcare spending per capita on different factors, using fixed effects for country and time period (fixed effects were not included in the table), without using Multiple Imputation. a represents significance at 1%.

3.7 Final Considerations

Throughout this paper we look at the amount of health expenditure as something high and problematic. Up until this point, it is important to analyze both the nature and magnitude of such concern about the amount of spending on health. We can also ask the question: from what point can we infer that such expenditures are high? Is there really an ideal amount for expenditure on health? Is this concern about the health sector legitimate? Are Would Health Economists exaggerating in the focus given to this phenomenon? Why are high healthcare costs bad?

"*We do not know that the current rate of medical spending growth is "too high" or that there are ways to slow it without doing more harm than good. We do know that there is more to medical care than spending, and more to medical spending than cos*t" (Pauly, 2003 pp. 26).

According to Pauly (2003), if we assume that the additional resources, which flow into the healthcare sector, are used to produce some good for health and welfare, then no kinds of preoccupation should exist around the amount and growth rate of this spending. However, one of the major problems surrounding the issues of health spending is the existent difficulty around the measurement of quantitative and qualitative return of such value invested. There is a problem in completely understanding truly how much effective spending is, i.e. how to evaluate the economically return of such investments and the possible contribution of this increase in spending on health.

Alternatively, part of the increase in health spending is '*an accounting illusion*', i.e., it "*does not involve any increase in real costs – only money costs*" (Fuchs, 1972, pp. 45). In recent decades, there has been a 'transfer' into the health market sphere (where services are paid) of certain healthcare activities that, at first were carried out in the family circle, as the case of bed care and services associated with the treatment of sick and elderly. In this sense, there has been a substitution to formal from informal care (Gerdtham *et al*, 1992a), which occurred due to inherent factors of the development of societies, such as the increase of urbanization, the increased participation of women in the labor market and the defragmentation of families, among others (Fuchs, 1972; Maxwell, 1981; Stahl, 1986).

On the other hand, there are also certain expenses, not only restricted to the health sector that will lead to a reduction in the future healthcare expenditure – spending on prevention measures, for example. This is prevalent in the case of anti-smoking campaigns, highway safety, food safety, screenings, and water sanitation, vaccines, among others (Orszag, 2008). In essence, these peculiarities that transform healthcare spending growth into a problem, reflect themselves in the excess of taxation burden, across intergenerational welfare, in the stimulation of the uninsured agent, in the peculiar structure of health

industry (essentially constituted by nonprofit organizations), and in the increase of moral hazard, more than is needed (Fuchs, 1972; Pauly, 2003).

For Fuchs (1972), there is a reason for concern because in the most developed countries, much of the increase in health costs continues to be supported by third parties, i.e., a great bulk of health expenditure is financed with the recourse to public funds collected through taxes or compulsory social insurance contributions (Gerdtham and Jönsson, 2000). This situation represents a particular dilemma for two reasons: first, as the taxpayers have to support a reasonable part of such increase through taxes collection, the compensatory increase in taxes may lead to a distortion in the agents' behavior in order to escape this obligation. Such distortion may have a cost in the sense that tax rates have to be raised further, in order to the government collect the same amount of revenue (Pauly, 2003). Secondly, the fact that governments incur a large part of that expense as well as its increase, threatens the solvency of public finances. This constitutes a barrier since the most developed countries have been consistently running budget deficits and the effort to contain health budgets may increase the already existing pressure on public budgets.

Another potential problem arises from intergenerational welfare, which comes from the pay-as-you-go mechanism of much of the systems present in most developed countries. The possible debt incurred today can effectively support the increase in health costs, which must be paid by future generations. In addition, the fact that increased costs in health sector also leads to an increase in insurance premiums, which in consequence can lead to a reduction in the number of insured persons, brings more problems eventually to the society, employers, employees, governments, and patients. In general, rising costs imply an increase in the number of uninsured people coupled with a decrease in the access to medical services to the poor, elderly and persons in ill health (Bodenheimer, 2005).

Several problems appear due to the fact that healthcare spending involves not only the budget of the public sector but also the budget of the private sector (households and insurance companies). This becomes an issue because households don’t have a great control over these expenses due to the urgency, fear, and pain involved in many medical episodes and due to the inexistence of technical knowledge necessary to face such

situations. According to Ginsburg (2008), these circumstances justify the fact that some economists are unwilling to accept the current proportion of GDP spent on healthcare as optimal.

3.8 Concluding Remarks

This paper considers different factors that affect healthcare spending using panel data and multiple imputation techniques. Through the development of a composite technological index and through the use of unique panel dataset that covers 27 countries over the years from 1975 to 2010, we found several interesting results from our analyses. First, a high estimated R^2 in our econometric analyses suggests that the determinants of healthcare expenditure that we proposed account for almost all the variability in healthcare expenditure *per capita* that we see.

Second, our econometric model introduces a composite technological index that has a positive impact on total healthcare expenditure *per capita*. This suggests that the introduction of new technologies contributes to the increase in healthcare expenditures verified in the last years, which is in accordance with the results obtained by the literature (Cutler, 1995; Newhouse, 1992; Okunade and Murthy, 2002). Our analysis of the technological index suggests that technology has a differential impact on costs depending on a country's stage of development of technology.

Results from Figure 3.4 further reinforce the conclusions obtained by Newhouse (1992) that technological innovation contributes positively to healthcare costs, given the fact that all countries, before 1992, were on the left side of the turning point. Moreover, by analyzing the non-linear effects of technology, we can also conclude that this increase in the healthcare expenditure *per capita* driven by technological innovation illustrates diminishing returns, fading away with its volume.

This allows us to conclude that more investment in technological innovation can efficiently save resources. Despite the initial effort of required investment, from certain point, additional investments are offset from efficiency gains through the use of technology. This fact may lead to an increase in global divergence between countries with respect to technological level in the healthcare sector, given the countries with a lower technological levels in healthcare (for example, according with our results, Mexico) doesn't benefit from the resource savings that countries with a higher technological level benefit (as seen in the USA or Switzerland), making them more prone to invest in technological innovation. This fact may also be amplified by the weak capacity of countries, with a lower technological level or capacity to invest in more technologies due to the initial star-up costs necessitated.

We also had robust findings for other variables in our model. Many of our conclusions, such as those regarding variables GDP_{pc}, OUTP, and GOV reinforced findings in the literature such as Barros (1998) and Okunade *et al*. (2004). Finally, our methodology produced robust and interesting results, suggesting that the use of panel data and multiple imputation techniques may be a viable approach to the analysis of trends in health expenditure. These conclusions remain unchanged even when we supplemented new independent variables in the regression or even when we integrate the variable PHARM in the technological composite index (model number 2), proving in this way the robustness of the analyses performed (see Figure A.5 in the Annex A). However, it is worth nothing that one of the limitations of this study is the non-consideration of ICTs on technological composite index. This happens due to the inexistence of variables able to reflect the use of the same on the healthcare sector.

Annex A

Table A.3. Variable names and definitions

Variable	Describe	Weight	
MRI	Magnetic Resonance Imaging units, total – *Per* million population.	0.06402	0.06232
PET	PET scanners, total – *Per* million population.	0.08426	0.8048
GAMMA	Gamma cameras, total – *Per* million population.	0.03028	0.02900
DSA	Digital Subtraction Angiography units, total – *Per* million population.	0.05627	0.05148
MAM	Mammography, total – *Per* million population.	0.07364	0.06887
RTE	Radiation therapy equipment, total – *Per* million population.	0.07441	0.07377
LITH	Lithotripters, total – *Per* million population.	0.02428	0.02151
MRIE	Magnetic Resonance Imaging exams, total – *Per* million population.	0.02805	0.02683
END	End-stage renal failure patients – *Per* 100.000 population.	0.09165	0.08900
DIA	Patients undergoing dialysis – *Per* 100.000 population.	0.0972	0.09220
FUKIDNEY	Functioning kidney transplants – *Per* 100.000 population.	0.05794	0.05357
BONE	Bone marrow transplants – *Per* 100.000 population.	0.05373	0.05019
HEART	Heart transplants – *Per* 100.000 population.	0.07295	0.07040
LIVER	Liver transplants – *Per* 100.000 population.	0.06361	0.05949
LUNG	Lung transplants – *Per* 100.000 population.	0.06422	0.06171
KIDNEY	Kidney transplants – *Per* 100.000 population.	0.06352	0.05987
PHARM	Total pharmaceutical sales *per capita*	-	0.04979

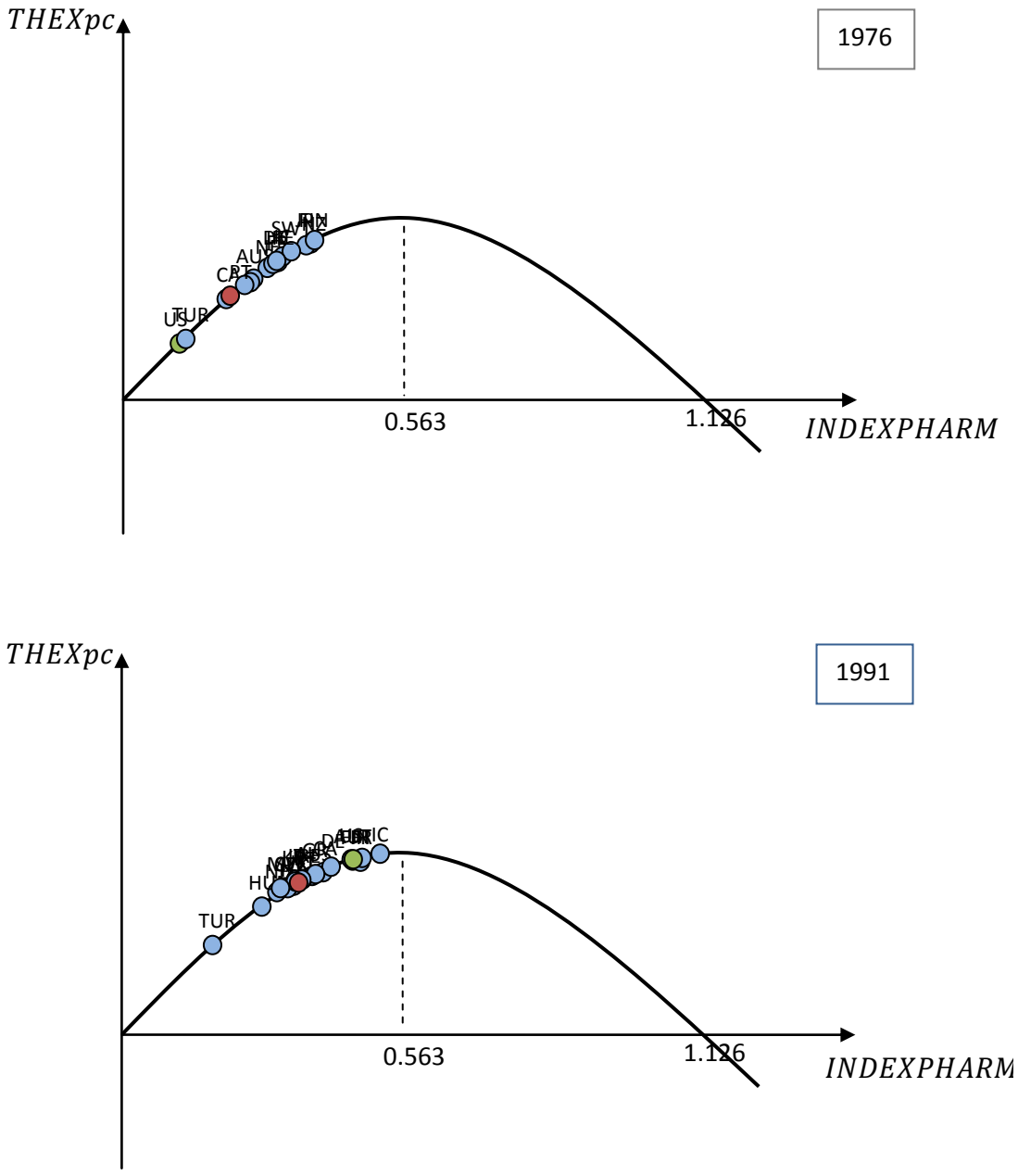
This table displays the variable names, definitions and respective weights of the variables that constitute the technological composite index.

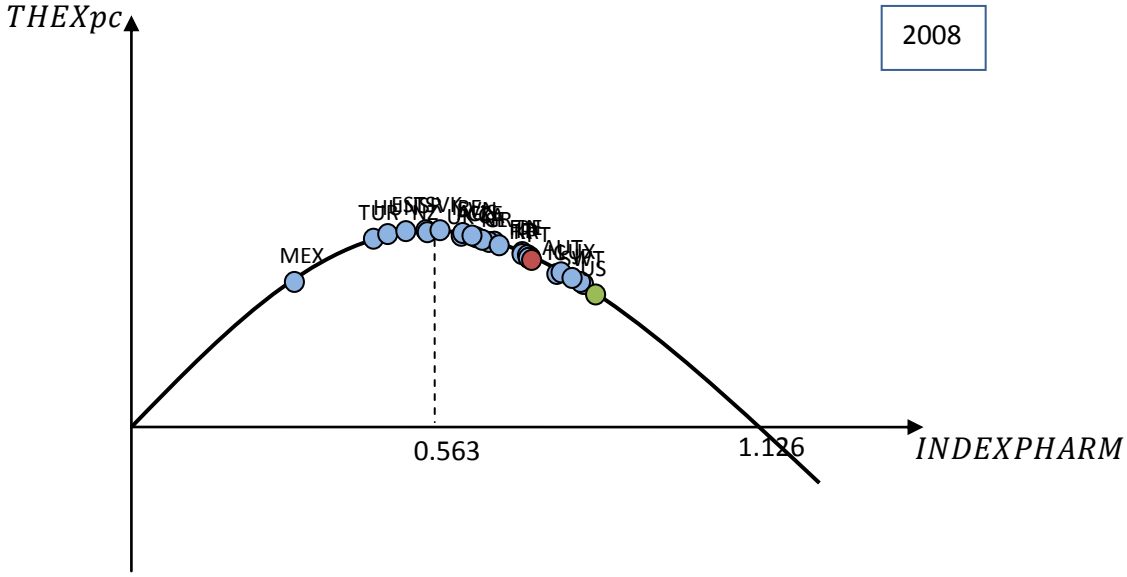
Table A.4. Descriptive statistics

Variable	Mean	St. Deviation	Min.	Max.
GDP_{pc}	9.71	0.61	7.74	11.4
URB	4.26	0.18	3.71	4.53
GOV	1.61	0.41	-0.65	2.28
PHARM	5.43	0.56	3.46	6.88
EMV	-3.46	0.43	-4.86	-2.38
IM	2	0.66	0.53	4.79
OUTP	4.23	0.37	3.12	4.6
POP14	-1.59	0.22	-2.01	-0.91
ALCOOL	2.21	0.53	0.13	3.02
SMOK	3.32	0.27	2.1	3.99
LEX	4.33	0.05	4.03	4.41
UNEM	1.71	0.66	-1.61	2.96
INDEX	0.30	0.079	0.00	0.778
INDEXPHARM	0.57	0.087	0.00	0.850

Note: This table presents the descriptive statistics of the explanatory variables.

Figure A.5. Contribution of technological innovation to healthcare costs, including the variable PHARM in the composite technological index





Note: These graphs were created from the database used in this paper and each of them shows the relationship between healthcare expenditure *per capita* and variable INDEXPHARM, over three years (1976, 1991 and 2008), for the countries in the sample for which we have data. In the third graph, the countries on the right side of the turning point (0.563) are: Australia, Austria, Canada, Czech Republic, Denmark, Finland, France, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Netherland, Portugal, Slovak Republic, Slovenia, Switzerland; UK and USA. The countries on the left side are: Estonia, Hungary, Israel, Mexico, New Zealand and Turkey.

Chapter 4

4. Rethinking the Impact of Healthcare Expenditure: New Empirical Evidence*

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4.1 Introduction

> "*We do not know that the current rate of medical spending growth is "too high" or that there are ways to slow it without doing more harm than good. We do know that there is more to medical care than spending, and more to medical spending than cost*".
>
> (Pauly, 2003 pp. 26)

Over the past sixty years, the growth of healthcare spending in developed countries became the center of comments and discussions among politicians, administrators and economists in many countries. Healthcare spending has become a source of concern due to its absolute value and its growth rate.

These concerns have raised some important questions regarding the amount of healthcare spending. At what point can we say that expenditure is high? Is there really an ideal level of health expenditure? Is this concern about the healthcare sector legitimate? Are health economists exaggerating by focusing so much on this phenomenon? Why are high healthcare costs bad?

According to Pauly (2003), if we assume that the additional resources, which flow into the healthcare sector, are used to produce some "good" for health and welfare, then there should not be that much concern about the amount of spending and the growth rate of this spending.

However, one of the major problems surrounding the problem of healthcare spending is the difficulty of measuring the quantitative and qualitative return of such value invested. It is difficult to completely understand how effective the spending is and to

evaluate the economic return of these investment and the possible contributions of these investments on health outcomes.

Hence, the purpose of this paper is to determine if the concern surrounding healthcare expenditure is legitimate and to evaluate the return of such expenditure in quantitative (life expectancy) and qualitative (morbidity and disability) terms. To this end, we construct a new health status measure able to combine mortality and morbidity into a single composite indicator for a single country at a point in time. Using a large panel dataset of thirty OECD countries, we estimate how various socio-economic, environmental, lifestyles, and technological factors affect health status indicator. Our results suggest that the concern about the amount of healthcare expenditure *per capita* should not be focused on the total expenditure *per se*, but instead directed to the amount of the expenditure financed by the government.

This chapter is organized as follow. Section 4.2 provides a review of population health status indicators. Section 4.3 presents the methodology used in the construction of our indicator, LEAPHS. The data, methodology, regression, and empirical results are presented in Sections 4.4 and 4.5. In Sections 4.6 and 4.7, we discuss the results and provide a conclusion.

4.2 Literature Review

Over the past sixty years, concern around the growth trend of healthcare expenditure in developed countries coupled with the need to evaluate the impact of such expenditure on a population's health status has resulted in increased attention to measuring the health status of the individual and the population and to measuring the impact of some factors on this health status.

Measuring population health is a vital prerequisite to creating effective public policy but also to assess the consequences of public interventions and/or socio-economic,

environmental, lifestyle and technological factors that may affect health status. A population's health can be measured using essentially macro-level and micro-level indicators. Whereas macro-level indicators provide a broad overview of population health status, micro-level data can only provide information about specific aspects or dimensions of health.

These health status indicators are usually used in econometric studies with the aim of determining the influence of some factors on individual and/or a population's health status. The choice of micro-level or macro-level indicators depends on the specific nature of the analysis.

4.2.1 Macro and Micro-level indicators

Macro-level studies often use mortality or longevity indicators because they are generally good proxies for the health status of the population, as well as available for long time periods and for a large sample of countries. Some commonly used mortality indicators are mortality rates, which can be age-specific, perinatal (early neonatal or foetal deaths), neonatal (deaths of children under 28 days of age) and infant mortality (under 1 year), all of which are expressed as the number of deaths per 1000 births. The most commonly used longevity indicator is life expectancy which can be measured at various ages, such as at birth, at 40, 60, 65 or 80 years old. Life expectancy is the average number of years that a person at the indicated age can be expected to live, assuming that age-specific mortality levels remain constant. Other commonly used longevity measures combine mortality and morbidity information, such as Disability-Free Life Expectancy (DFLE); Health-Adjusted Life Expectancy (HALE); Quality-Adjusted Life Expectancy (QALE); Potential Years of Life Lost (PYLL); Disability-Adjusted Life Years (DALY); and Quality-Adjusted Life Years (QALY) (Cochrane *et al.*, 1978; Joumard *et al.*, 2008; Or, 2001; Santerre *et al.*, 1991).

For example, life expectancy at birth is used as a health outcome to analyze the impact of medical care services and other factors (Afonso and St Aubyn, 2006; Babazono

and Hillman, 1994; Barlow and Vissandjee, 1999; Crémieux *et al*., 2005; Lichtenberg, 2000; Miller and Frech, 2002; Nixon and Ullman, 2006; Or *et al*., 2005; Puig-Junoy, 1998; Retzlaff-Roberts *et al*., 2004; Soares, 2007; Spinks and Hollingsworth, 2009; Wolfe and Gabay, 1987). Generally, this health outcome is separately measured by gender because, according to several empirical studies, healthcare systems have different impacts on health according to gender and in particular healthcare systems can have more impact on a woman's health than a man's health (Joumard *et al.*, 2008; Or, 2000; Silver, 1972).

Although most authors use life expectancy at birth, some authors prefer to use life expectancy at different ages other than birth. For example, Miller and Frech (2002) and Wolfe and Gabay (1987) use life expectancy at 60; Crémieux *et al*. (2005) and Or *et al*. (2005) use life expectancy at 65; Shaw *et al*. (2002) use life expectancy at 40, 60 and 65; and finally Babazono and Hillman (1994) use life expectancy at 80 years.

Some authors prefer to use infant mortality to life expectancy because the data are more readily available, and compared with adult mortality this indicator has more economic significance in terms of forgone production. Further, governmental healthcare policies seem to have a greater impact on mortality during infancy, and some factors such as alcohol, tobacco consumption, and education (factors not related to the healthcare system) have less impact on infant mortality than on life expectancy (Babazono and Hillman, 1994; Berger and Messer, 2002; Cochrane *et al*., 1978; Crémieux *et al*., 1999 and 2005; Elola *et al*., 1995; Filmer and Pritchett, 1997; Grubaugh and Santerre, 1994; Hitiris and Possnett, 1992; Leu, 1986; Miller and Frech, 2002; Nixon and Ullman, 2006; Retzlaff-Roberts *et al*., 2004; Robalino *et al*., 2001; Verhoeven *et al*., 2007).

Mortality rates are widely used and some authors claim they are "*objectively measured, relatively precise and readily available*" (Or, 2000, pp. 55), but they are rather limited as indicators of healthcare outcomes because they do not consider the quality of life and/or level of disability. They do not differentiate between the longevity that results in increased time spent in good health and, in contrast, the increased time spent with disease or disability (Joumard *et al*., 2008).

Due to this limitation, some international organizations, such as the World Bank and European Commission, have created some health status indicators that combine mortality and morbidity to the same indicator. The most important and most widely used of these indicators are HALE (first designed by Disability-Adjusted Life Expectancy – DALE), QALE, DALY, PYLL, QALY, and DFLE.

Some of these health measures are typically used in cost-effectiveness analysis of healthcare interventions to provide information about the benefits gained from such medical procedures and/or treatments. One example of such indicators is the QALE, which takes into account, usually for a given disease, the quantity and quality of the survival years generated by different types of medical interventions and treatments, using as a unit of "measure" the QALY (Masseria *et al.*, 2007).

QALY allow measuring the state of health of a person or population to be adjusted by the quality of life. According to the National Institute for Health and Care Excellence, this measure is calculated "*by estimating the years of life remaining for a patient following a particular treatment or intervention and weighting each year with a quality of life score (on a zero to one scale). It is often measured in terms of the person's ability to perform the activities of daily life, freedom from pain and mental disturbance*" (NICE, 2013).

In contrast to the QALY, there is also the DALY. While QALY are a positive concept (healthy life years gained), DALYs represent healthy life years lost: the sum of PYLL lost due to premature mortality and the years of productive life lost due to disability (YLD) (WHO, 2013 b). One QALY (DALY) is one gained (lost) year of healthy life.

Besides being used as a health macro-level indicator *per se*, DALYs are also used as an integral part of another important macro-level indicator – the HALE.

HALE represents the average number of years that a person can expect to live in "full health" by taking into account years lived in less than full health due to disease and/or injury" (WHO, 2013 a). In the HALE the years spent in unhealthy states are subtracted from overall life expectancy and weighted according to the severity of the unhealthy state.

The difference between life expectancy and HALE corresponds to the equivalent person-years of life lost due to disability.

DFLE is similar to the HALE. However, the indicator is not adjusted by the severity of the illness (Joumard *et al.*, 2008).

PYLL is a "summary measure of premature mortality, which provides an explicit way of weighting deaths occurring at younger ages, which are, a priori, preventable. The calculation of PYLL involves summing up deaths occurring at each age and multiplying this with the number of remaining years to live up to a selected age limit" (OECD, 2012). "DFLE is the average number of years an individual is expected to live free of disability if current patterns of mortality and disability continue to apply" (OECD, 2001).

Due to the lack of time series data and rare country coverage of these indicators, there are not as many studies that use these kinds of indicators compared to the other macro-level indicators. Some studies that use the DALE include Miller and Frech (2002), Self and Grabowski (2003), and Verhoeven *et al*. (2007). Or (2000 and 2001) used premature mortality as an outcome, instead of conventional crude death rates, represented by the number of PYLL. This approach is also used by Afonso and St Aubyn (2006), Elola *et al*. (1995), and Miller and Frech (2002).

Most of the health-adjusted life expectancy measures presented above are essentially based on micro-level health measures, because micro-level health measures include detailed clinical, behavioral, and personal information, using disease-specific measures such as blood pressure, eyesight, observed ability to carry out activities of daily living (ADL), body mass index, the Short form 36-item Health Survey (SF-36), the EQ-5D (Euroqol, 2013), and the Health Utility Index (Dolan *et al.*, 1995; Torrance, 1986).

SF-36 is a health-related quality of life measure constituted by 36 questions "*which measure eight multi-item variables: physical functioning (ten items), social functioning (two items), role limitations due to physical problems (four items), role limitations due to emotional problems (three items), mental health (five items), energy and vitality (four*

items), pain (two items), and general perception of health (five items)" (Jenkinson *et al*., 1993, pp. 1437).

4.2.2 The main determinants of healthcare outcomes

According to the definition by the WHO (1948) health is "*a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity*", which means that health is affected by a multitude of different factors not only inherent to the individual, for example genetics (some people have a higher probability of developing certain diseases); gender (men and women suffer from different types of illnesses at different ages), and age, but also lifestyle habits (drinking, smoking, diet); education level; the use of healthcare resources: socio-economic factors; and the physical environment (safe water and clean air).

In light of the multidimensional nature of health, studies analyze the different determinants that together affect the health of individuals and communities. The first studies to emerge were done by Auster *et al*. (1969), Hadley (1982), Newhouse and Friedlander (1980), Silver (1972). These studies used data from the United States (USA) for the period of 1972 and earlier.

For example, Auster *et al*. (1969) analyzed the relationship of mortality of whites individuals to both medical care and some environmental variables, concluding that environmental variables, especially education and income, are more important than medical care. They used age-adjusted death rates as the measure of health status. Independent variables include income, percent nonwhite, education, alcohol and cigarette consumption per capita, percent employed in manufacturing, standard metropolitan statistical areas, percent in white-collar occupations, females not in the labor force, and a dummy variable coded 1 for states with medical schools and 0 for those without.

Using micro data from 1959 to 1962, Newhouse and Friedlander (1980) estimated a health production function using morbidity measures and six physiological measures (for example, blood pressure and cholesterol).

Following the same framework, Berger and Leigh (1989) and Kenkel (1991) also estimated health production functions with the following explanatory variables: blood pressure, schooling, health knowledge, self-reported health status, and other observable variables.

These studies served as the foundation for the emergence of more detailed studies about the determinants of health status such as Afonso and St Aubyn (2005), Bhat (2005), Economou and Giorno (2009), Jönsson (1990), Leu (1986), Retzlaff *et al*. (2004), Schwellnus (2009), Siddiqui and Mahmood (1994), Spinks and Hollingsworth (2009), ,and Santerre *et al*. (1991).

The variety of the health's determinants considered in these studies is significant, with some determinants more important, and consequently more used, than others. Despite the mixed empirical results, there is a general consensus about the factors that affect the population's health status. These factors include healthcare services, socio-economic factors (wealth, safety regulation, infrastructures), lifestyle factors (tobacco, alcohol and consumption of fruits, sugar, vegetables or calorie intake), environmental conditions (pollution), institutional factors, and finally technological factors.

For example, to measure the impact of medical care on health outcomes most empirical studies use, as a *proxy* for the quantity of healthcare services consumed, some form of healthcare expenditure. Healthcare expenditure *per capita* is used by Babazono and Hillman (1994), Barlow and Vissandjee (1999), Berger and Messer (2002), Crémieux *et al*. (1999), Elola *et al*. (1995), Hitiris and Posnett (1992), Lichtenberg (2000), Nixon and Ullman (2006), and Or (2000).

Other authors, such as Cochrane *et al*. (1978), Nixon and Ullman (2006), Retzlaff-Roberts *et al*. (2004), have measured healthcare expenditure by using health expenditure as a share of Gross Domestic Product (GDP).

Still others have used the share of healthcare spending financed by the public sector (Berger and Messer, 2002; Babazono and Hillman, 1994; Elola *et al*., 1995; Filmer and Pritchett, 1999; Or, 2000; Or *et al*., 2005), while other authors have used some specific

health spending components. For example, Babazono and Hillman (1994), Lichtenberg (2000), Miller and Frech (2002), and Shaw *et al*. (2002), use pharmaceuticals spending. In turn, Afonso and St Aubyn (2006), Cochrane *et al*. (1978), Crémieux *et al*. (1999), Grubaugh and Santerre (1994), Babazono and Hillman (1994), Leu (1986), Nixon and Ullman (2006), Or (2001), Or *et al*. (2005), Puig-Junoy (1998), Retzlaff-Roberts *et al*. (2004) use physical healthcare resources (as the number of hospital beds, the doctors per capita or the number of consultations per capita).

Relative to socio-economic factors the most used variables are: income *per capita*; education (the proportion of the adult population that is literate – Barlow and Vissandjee (1999), the proportion of the population aged over 25 years with post-secondary education – Berger and Messer (2002), education index – Cochrane *et al*. (1978), the number of years of education – Self and Grabowski (2003), and real educational expenditures *per capita* – Grubaugh and Santerre (1994)), poverty, urbanization (the urban population as a proportion of the total population – Barlow and Vissandjee (1999), population density – Crémieux *et al*. (1999 and 2005), Grubaugh and Santerre (1994)), occupational status (proportion of white-collar workers in the total work force – Or (2000)), aging (percentage of population aged over 65 years – Hitiris and Posnet (1992), Wolfe and Gabay (1987)), and unemployment (Nixon and Ullman, 2006; Spinks and Hollingsworth, 2009).

Most of the empirical studies in the area include the consumption of tobacco and alcohol in the analysis, as well as some *proxies* for dietary consumption (consumption of fruits, sugar, vegetables or calories intake) in order to grasp the influence of lifestyle on health status (Afonso and St Aubyn, 2006; Berger and Messer, 2002; Cochrane *et al*., 1978; Crémieux *et al*., 2005 and 1999; Nixon and Ullman, 2006; Puig-Junoy, 1998; Shaw *et al*., 2002; and Wolfe and Gabay, 1987).

Environmental factors are essentially represented by pollution (Nixon and Ullman, 2006; Or, 2001; Shaw *et al*., 2002) and crime (Thornton, 2002).

Some studies also include institutional factors such as: the type of health system (social security *versus* an integrated national health service – Elola *et al*., 1995), the provider payment systems at the hospital and individual level, the access arrangements

(gatekeeper role – Or, 2001), the public spending share in healthcare spending; the provider payment systems in the hospital and ambulatory sectors; the access to public medical care and immunization coverage (Soares, 2007), the proportion of population eligible for in-patient care benefits under a public health scheme; the proportion of population eligible for ambulatory care benefits under a public scheme (Berger and Messer, 2002), the proportion of the population aged under 15 years; and some structural indicators (political rights, corruption, ethnicity – Robalino *et al*., 2001).

However, it is rare for studies to include the effects of technological innovation on health status in their models. Sometimes, technological innovation appears as a component of physical healthcare resources (Afonso and St Aubyn, 2006; Or *et al*., 2005; Retzlaff-Roberts *et al*., 2004). Only Grubaugh and Santerre (1994) included a specific variable into their analysis with the aim of measuring the impact of technology. To this end, they used a time trend as a *proxy* for technology.

According to the main objective of this study and as explained above it has became vital to construct a new health indicator, which includes not only the quantity but also the quality of a population's health, associated with a large sectional and temporal sample. In the next section we will be describe the steps needed for the construction of such an indicator.

4.3 The indicator – LEAPHS

> *"…as long as we are unable to put our arguments into figures, the voice of our science, although occasionally it may help to dispel gross errors, will never be heard by practical men. They are, by instinct, econometricians all of them, in their distrust of anything not amenable to exact proof."*
>
> Schumpeter (1933, pp. 12)

> *"Give me a measure – a single measure – which is as vulgar as GNP per capita, but not as insensitive to broader aspects of human life."*
>
> Mahbubul Haq

A historical analysis shows that, after the second half of the twentieth century, the world has seen a significant improvement in overall health status of the population, which was reflected in a significant reduction in mortality and progressive increases in longevity (WHO, 2010).

Over the last century, life expectancy at birth has increased progressively whereas infant mortality has declined dramatically. Between 1960 and 2005, in OECD countries, life expectancy at birth increased by almost ten years on average, and infant mortality has been reduced by a factor of seven (Joumard *et al*., 2008). More recently, the death rates among the older population also began to decline. People are living longer. However, are these extra years of life in the same or better health, or are they spent in illness and dependency?

In order to be able to answer this question it is necessary to evaluate the quality of years lived, through the extension of the concept of life expectancy (mortality) to morbidity and disability. In this way, it is important to create an indicator that can evaluate not only the quantity of years lived but also the life quality of those years by adding a dimension of quality to the quantity of life lived.

With the aim of answering this question different indicators associate the number of years lived (life expectancy) with the quality of those years, through the association of mortality and morbidity and disability information. Some examples of such indicators are: HALE; DFLE; DALYs and QALYs.

Due to the specificity of DALYs and QALYs (they are only applied to one disease or treatment), lack of time series data and rare country coverage of HALE and DFLE, we decided to construct a new health status indicator that combines mortality and morbidity, through the adjustment of life expectancy to the quality of years lived – Life Expectancy Adjusted by Perceived Health Status (LEAPHS).

The methodology used in the construction of our indicator, which will be explained, has some advantages over other health status measures. First, it is easy to explain the concepts that involve LEAPHS (perceived health status, life expectancy, life in good health) to a non-technical audience.

Second, in clear opposition with the most used indicators (DALY, QALY, HALE and DFLE), one can calculate LEAPHS across many years and many countries.

Third, the LEAPHS units and measurement are intuitive.

Finally, perceived health status is used to calculate LEAPHS, and hence, can capture some factors that affect the health status of the individuals, which are not captured by other measures, such as education, income level, housing, marital status, employment and economic development as argued by Alexopoulos and Geitona (2009), Capik and Bahar (2008), Cox *et al.* (1988), Kaleta *et al.* (2009), Maddox and Douglass (1973), and Shields and Shooshtari (2001). For example, Maddox and Douglass argue "*Self health*

ratings are clearly measuring more than simple morale," (Maddox and Douglass, 1973, pp.92).

4.3.1 Methodology

The construction of the LEAPHS is done in three stages. In the first stage, we calculate mortality risk for specific age and gender groups. This first stage is done following a standard method in the literature called the Sullivan method. In the second stage, we combine the mortality risk, calculated for specific age and gender groups with the perceived health status for the same age and gender groups. Morbidity is encompassed in the perceived health status ratings. In third stage we use the formula developed by Sullivan to calculate the LEAPHS, using the information collected in the previous stages. Hence, in this way, our indicator is able to account for mortality risk and morbidity.

To be able to calculate the LEAPHS, the researcher needs:

- Mortality risk data from standard life tables, available from most countries in most years;

- Perceived health status data, available from most countries, which can be used to calculate morbidity risk.

We next describe the three stages of calculation of the LEAPHS.

4.3.1.1. First stage of the calculation of LEAPHS

For the construction of LEAPHS we resorted to a common method in the literature proposed by Sanders (1964) and later developed by Sullivan (1971a) – the Sullivan method. The Sullivan method is used to calculate health expectancy (mortality risk) for different age groups, from different life tables.

The first life table was sketched by John Graunt in 1691, but only in 1693 appears the first life table based on really scientific principles elaborated by Edmund Halley. Life tables are statistical models that combine mortality rates at different ages, turning them into mortality quotients. This allows, through the association of a set of basic functions, the measurement of the phenomenon of mortality – the deduction of the probabilities of survival and life expectancy. Contrary to what happens with crude mortality rates, life tables have the advantage of not being affected by the age structure of the population. Generally life tables are calculated for each sex separately and together (Carrilho and Patrício, 2004).

Table 4.5. Portugal, Life tables, Total

Year	Age	m_x	q_x	a_x	l_x	d_x	L_x	T_x	e_x
2004	0	0.00432	0.00430	0.06	100,000	430	99,594	7,493,711	74.94
2004	01-04	0.00037	0.00149	1.52	99,570	148	397,911	7,394,117	74.26
2004	05-09	0.00021	0.00103	2.75	99,421	102	496,877	6,996,206	70.37
2004	10-14	0.00019	0.00096	2.84	99,319	95	496,391	6,499,329	65.44
2004	15-19	0.00060	0.00299	2.81	99,224	296	495,472	6,002,938	60.50
2004	20-24	0.00098	0.00491	2.41	98,928	485	493,383	5,507,466	55.67
2004	25-29	0.00125	0.00622	2.64	98,443	612	490,769	5,014,084	50.93
2004	30-34	0.00164	0.00817	2.59	97,831	800	487,224	4,523,314	46.24
2004	35-39	0.00229	0.01140	2.56	97,031	1106	482,460	4,036,090	41.60
2004	40-44	0.00324	0.01606	2.61	95,925	1540	475,948	3,553,631	37.05
2004	45-49	0.00461	0.02282	2.61	94,384	2154	466,764	3,077,683	32.61
2004	50-54	0.00628	0.03096	2.60	92,231	2855	454,295	2,6109,18	28.31
2004	55-59	0.00845	0.04141	2.59	89,375	3701	437,940	2,156,623	24.13
2004	60-64	0.01316	0.06380	2.63	85,675	5466	415,436	1,718,683	20.06
2004	65-69	0.02033	0.09702	2.64	80,209	7782	382,710	1,303,247	16.25

Note: In this table we present an example of a life table for Portugal in the year 2004. Here, we have the year, different age groups, eg. x to x + n, where n can be 1, 5 or 10, the central mortality rate x and x + n (m_x), probability of dying between age x and x + n (q_x), the median survival time between ages x and x + n for people who die in the interval (a_x), the number of survivors at age x, assuming l_0=100.000 (l_x), number of deaths between ages x and x + n (d_x), the number of person-years lived between ages x and x + n (L_x), the number of person-years remaining after age x (T_x), and life expectancy in years at age x (e_x).

To use Sullivan's method it was necessary to collect some variables in order to construct the mortality component of the indicator: (1) the number of survivors at exact age x, assuming that at age 0 the number of survivors is 100,000 (l_x), (2) deaths or specific

mortality rates, (3) the number of person-years lived between ages x and $x + n$, (where n can be equal to 1, 5 or 10, for example), from the abridged life table (L_x), and (4) the number of person-years remaining after exact age x.

This method multiplies the total number of person-years lived between ages x and $x + y$, from the abridged life table (L_x) by the corresponding severity-weighted prevalence of disability (d_x) to calculate the equivalent healthy person years of life lost to disability at different ages. The number of person-years lived in good health between ages x and $x + y$ is then calculated by separating the person-years of life lost to disability from the total number of person-years lived inside the age range (up to x+n). After this step, it is possible to obtain our indicator using the traditional method used in the calculation of life expectancy.

In order to be able to combine the mortality and morbidity components we need to construct abridged life tables, this is, life tables with age intervals greater than one year, for all countries in the sample. In our case we calculate the mortality risk for the following age groups: 0 to 14 years, 15 to 24 years, 25 to 44 years, 45 to 64 years, and 65 and over. In this way, the mortality component was obtained from the life table for all of the countries present in the sample.

4.3.1.2. Second stage of the calculation of LEAPHS

The morbidity information used for the construction of LEAPHS comes from the OECD Health Data 2012 – Percentage of the population, aged 15 years old and over who report their health to be "good" or "better" (perceived health status, by age and gender). In this way, our indicator adds a dimension of quality (morbidity) to the quantity of life, measuring the average number of years that a person can expect to live in "good" or "better" health.

In the last several years, the European Union has decided to include in its European Community Health Indicators some health expectancies measures of disability, chronic

morbidity and perceived health, truly comparable between countries. This allowed us to use perceived health status, by age and gender, as the morbidity component. With this, we avoid the use of a different measure for quality of life for the different countries in the sample (EHEMU, 2012).

Additionally, self-reported health, by combining the individual's subjective experience of different states of health (such as of different diseases) with daily feelings of general well-being (tiredness, headaches, etc.), allows us to get a consistent and valid measure of general physical health (Davies and Ware, 1981; Mossey and Shapiro, 1982). In the end we have a health measure that is generally in line with the WHO's definition of health, because self-reported health is highly correlated with other indicators of morbidity and mortality and is a stronger predictor of mortality than is physician assessed health (Idler and Kasl, 1991; Mossey and Shapiro, 1982; Ross and Wu, 1995).

Self-reported health is not only a function of actual health status, but it is also affected by individual or population groups' perceptions of health, and hence it is recommended both by the WHO and the European Commission as a reasonably realistic predictor of total mortality, psychological and medical symptoms, as well as return to work (state of health) (European Commission, 2010). Additionally, some studies show that self-reported health is consistent with a doctor's evaluation (Hunt *et al*, 1980).

4.3.1.3. Final stage of the calculation of LEAPHS

After we collected the two components needed to calculate our indicator, this is, (i) mortality risk by age groups, (ii) perceived health status by age groups (from which we will calculate morbidity for different age groups) we are able to construct LEAPHS, according to the next equation:

$$\boldsymbol{LEAPHS = \frac{1}{l_x}\sum_{x=1}^{C}\left(L_x * \left(\frac{w_x}{100}\right)\right).}$$

The morbidity component of the indicator appears in w_x, this is, the percentage of the population with "good" or "better" health with ages in the interval $(x; x + y)$, and the mortality component is represented by L_x. C represents the number of age categories, which in our case are five.

In this way, LEAPHS reflects the life expectancy of a specific population adjusted by the perceived health status of that population. Given the health status of the population can vary significantly by gender we construct this indicator separately for men and women (Haber, 1967; Jagger, 1997; Kaplan and Erikson, 2000, Sullivan, 1971 b).

4.4 Model, Methodology and Data Description

In order to determine if the concern surrounding healthcare expenditure is legitimate and in order to evaluate the return of healthcare expenditure in quantitative and qualitative terms we use data from different OECD sources and from the World Bank. The unbalanced database covers 30 OECD countries, from 1980 to 2011, although some countries are not covered for all 31 years. The set of countries in the sample is constituted by Australia (1989-2007), Austria (2004-2010), Belgium (1997-2008), Canada (1994-2007), Chile (2000-2005), the Czech Republic (1993-2008), Denmark (2003-2009), Estonia (2002-2009), Finland (1979-2009), France (2002-2009), Germany (1998-2009), Hungary (2000-2009), Iceland (1998-2010), Ireland (1998-2009), Israel (2001-2009), Italy (1994-2008), Japan (1980-2009), Luxembourg (1996-2009), Norway (1995-2008), Netherlands (1982-2009), New Zealand (1997-2007), Poland (1996-2009), Portugal (2003-2009), the Slovak Republic (2004-2009), Slovenia (2004-2009), Spain (1987-2009), Sweden (1992-2007), Switzerland (1992-2007), United Kingdom (1991-2004)) and the USA (1981-2009). These countries were selected because they are relatively homogeneous in terms of their stage of economic development and real *per capita* income.

We build on earlier studies by using a new dependent variable – Life Expectancy Adjusted by Perceived Health Status – and a new explanatory variable, the technological composite index, to control for technological innovation in healthcare.

The other explanatory variables were selected based on theorized relationships to the dependent variable, specifically on past studies that suggest various socio-economic, environmental, lifestyle and technological determinants that influence the health status of the population. The descriptive statistics of the explanatory variables are shown in Annex B, Table B.8 and include the minimum value, average, maximum, and standard deviation for each variable.

In order to contemplate some socio-economic and environmental factors, we use as explanatory variables the Gross Domestic Product *per capita* in US dollars, converted at economy-wide Purchasing Power Parity (PPP) (GDP_{pc}); total health expenditure *per capita*

in US dollars, converted at economy-wide PPP (HE_{pc}); and the proportion of the urban population (URB).

As most chronic diseases, like obesity, diabetes or cerebrovascular diseases are related to some human behaviors, alcohol consumption in liters *per capita* (ALCOOL), tobacco consumption – cigarettes *per smoker per day* (SMOK), and total fat intake in grams *per capita per day* (FAT) were included in the model to account for lifestyle factors that affect health.

We also introduced some institutional variables such as health expenditure financed by the Government as a percentage of total healthcare spending (GOV); total health and social employment *per* million of the population (head counts) (THSE); the total number of hospital beds *per* million of the population (BED); and total public spending on education (as a percentage of GDP) (EDUC). Finally we use our technological composite index (INDEX).

The "health production function" is the following:

$$\mathbf{LEAPHS_{it}} = \boldsymbol{\beta_0} + \sum_{\mathbf{k=1}}^{\mathbf{11}} \boldsymbol{\beta_k} \mathbf{X_{kit}} + \boldsymbol{\beta_{12}} \mathbf{Index_{it}} + \boldsymbol{\beta_{13}} \mathbf{Index_{it}^2} + \sum_{\mathbf{i}}^{\mathbf{30}} \boldsymbol{\mu_i} \mathbf{d_i} + \mathbf{e_{it}}$$

$$\mathbf{X} = \{\mathbf{GDP_{pc}}, \mathbf{HE_{pc}}, \mathbf{URB}, \mathbf{ALCOOL}, \mathbf{SMOK}, \mathbf{GOV}, \mathbf{THSE}, \mathbf{BED}, \mathbf{EDUC}, \mathbf{FAT}\}.$$

The 30 d_i are dummy variables corresponding to the 30 countries in the sample. The introduction of dummy variables for the countries was necessary in order to control for any factors that are fixed within each country. There exist some country specific charactersitics (such as the type of healthcare system; the method and organization of production; the climate, the economic, technological, demographic characteristics, and other national differences) that influence the performance of the healthcare system and

consequently the health outcomes, which are not captured by the other explanatory variables present in the regression.

The explanatory variables in the regression are in log form, so the coefficients associated with these variables represent semi-elasticities, i.e., the increment in the average life expectancy adjusted by the perceived health status originated by an increase of 1% in the independent variable. For example, it is estimated that an increase of 1% in X_1 will increase the average life expectancy adjusted by perceived health status by $\frac{\widehat{\beta}_1}{100}$ years, *ceteris paribus*.

4.5 Empirical Results

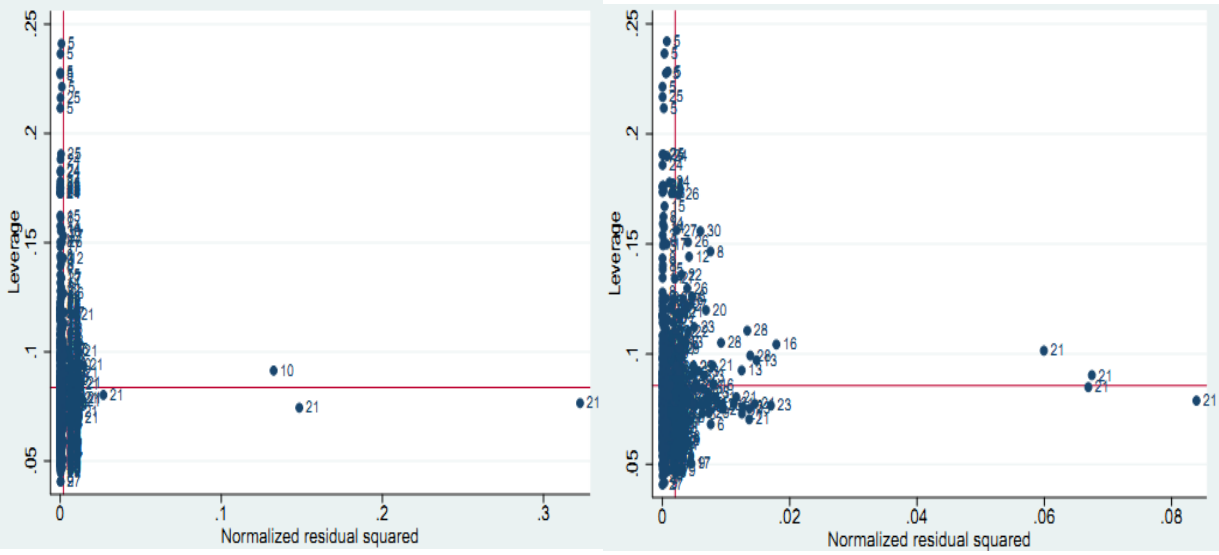
In this section we report our empirical results (Table 4.6) by applying robust regression as the estimation technique (Huber, 1964). Despite the fact that Ordinary Least Square (OLS), or other methods of regression, have favorable properties in comparison with robust regression, the use of robust regression aims to overcome some limitations of traditional parametric and non-parametric methods, allowing, amongst other things, the mitigation of the effects of possible outliers and the preservation of the order, dispersion, and symmetry of the database.

For these reasons, we decided to use robust regression due to the identification of outliers in the database (as we can see in Figure 4.6, where the countries France (10) and New Zealand (21) have either high leverage or a large residual), through the use of classical regression diagnostics techniques adapted to imputed data, and due to the existence of possible heteroscedasticity in the data. The regression model was estimated using STATA 12.0.

In order to address different statistical problems, as the existence of endogenous variables, we decided to estimate our regression using fixed effects instead of using

instrumental variables, because it is very difficult to find a obvious instrumental variables capable of overcome such problem.

Figure 4.6. Leverage *versus* Normalized residual squared, for men (left) and women (right)



Note: This figure was created from the dataset used in this paper to analyze the existence of outliers. We can see that France (10) and New Zealand (21) have high leverage and large residual.

Table 4.6 presents our results for the estimation of our "health production function". Here we show how our health measure, LEAPHS, is affected by the variables in, our model, according to gender.

Table 4.6. Estimated coefficients by 1-Fixed Effect Model (FEM) for LEAPHS

Variables	Women	Men	Percentage of variable impuated
GDP *per capita*	2,99[b]	4,12[a]	-
Health expenditure *per capita*	3,26[a]	2,01[b]	-
Urban population	-26,44[a]	-18,56[a]	-
Alcohol consumption	-1,04	-2,05[b]	--
Tobacco consumption	-0,20	-0,05	-
Fat intake	2,15	1,99	2%
Health expenditure financed by	-4,28[a]	-5,63[a]	-
Health and social employment	-0,12	0,44	21%
Hospital beds	1,09[c]	0,38	17%
Public spending on education	1,00	1,53[b]	10%
INDEX	-6,54[a]	-6,63[a]	70%
INDEXSQ	7,06[a]	7,07[a]	70%
Constant	139,54[a]	105,75[a]	-
R^2	0,982	0,981	-
F-statistic	374,91	481,07	-
F-test	0.000	0.000	-
F-test against 0 - FEM	166,84[a]	189,13[a]	-

Note: Here we regress LEAPHS, according to gender, on different factors, including a technologic composite index, using fixed effects for country (fixed effects were not included in the table). a, b, c represent 1%, 5% and 10% levels of significance.

4.6 Discussion of main results

As the aim of this paper is to analyze the impact of healthcare spending and technological innovation on the health status of the population, in the next section we will focus on total health expenditure *per capita*, health expenditure financed by the Government, and the technological composite index.

Through the statistical analysis (F-statistic and F-test) it is possible to conclude that the model is statistically significant (we reject the null hypothesis that all of the slopes equal zero). The larger the F-statistic, the more useful is the model. This is also corroborated by the high value of R^2, which means that approximately 98% of the variance of LEAPHS is accounted for by the model.

We found that the best fit for the data was a model in which fixed effects were used both for countries and time compared to when we used fixed effects for just countries (F-test against 1-FEM, C), or when we did not use fixed effects (F-test against 0-FEM). All the test results are statistically significant, which supports the decision of using 1-way fixed effects models, for country.

In general, the determinants present in the regression are relevant for the health of both men and women. However, we obtain different results by gender because throughout life the distribution and consequences of such determinants are different for each gender.

Male/female differences in mortality and morbidity are essentially due to individuals' different social roles, through marriage, parenthood, and employment; different lifestyle behaviors, such as cigarette smoking, and biological factors that also influence male/female mortality differences, particularly in infancy and prenatal life (Wingard, 1984). If we assume that individuals have different inter-temporal preferences, such differences may help to explain the variation in the consumption of cigarettes, alcohol, food and so on.

According to Jourmand *et al*. (2008) and Afonso and St Aubyn (2006), GDP *per capita* is the most important determinant of health status. We expect a positive impact of

GDP *per capita* on a population's health status because, higher income is related to higher quality of life. That is higher income may enable individuals to obtain better nutrition, housing, sanitation, public hygiene, schooling, etc., contributing in this way to reductions in premature mortality and improvements in life expectancy, both for men and women (Or, 2001; Siddiqui and Mahmood, 1994; Wilkie and Young, 2009;).

In this study, healthcare expenditure *per capita* is used as a *proxy* for the quantity of medical services provided to the population. According to Hadley (1982) this variable is preferable to the quantity of medical providers because variations in healthcare spending across countries better reflect the differences between the quantity and quality of medical services provided. Hence, we expect a positive relationship between healthcare spending *per capita* and our indicator. This is true for both genders in our study, which is consistent with the results obtained by Wolfe (1986); Crémieux *et al.* (1999); Hitiris and Posnett (1992); Jourmand *et al.* (2008).

The effect of urbanization on the health status of populations can be ambiguous because it involves not only positive but also negative health related factors. On one hand people in cities have easier access to health care, education, food, and housing without bearing large transportation costs, on the other hand they are also subject to higher levels of pollution, congestion, road trauma and a higher burden of stress. People exposed to stressful lives have a higher risk of suffering from poor physical health, psychological distress, psychiatric disorders and substance abuse (Jemmot and Locke, 1984; Kessler *et al.*, 1985; Turner and Lloyd, 1995). According to our results the negative urbanization effect dominates the positive effect for both genders when we consider the average life expectancy adjusted by perceived health status.

Alcohol consumption is associated with an increased risk of liver cirrhosis, cardiovascular diseases and certain types of cancers. It is also linked to accidents and injuries, violence, problems at work, homicides and suicide (OECD, 2009). According to Substance Abuse and Mental Health Services Administration (SAMHSA) (2010) women drink less alcohol and have fewer alcohol-related problems than men. Such phenomenon can be attributed to biological and psychosocial factors such as genetic factors, alcohol

reactivity or sensitivity, social sanctions, gender roles, motives and expectancies, etc. (Blume, 1991; Gomberg, 1988; Nolen-Hoeksema, 2004). These factors can explain in part the different results obtained in men and women, as it is statistically significant for men but not for women (Ross and Bid, 1994). According to Or (2001) and McCartney *et al.* (2011), the impact of alcohol consumption on male premature mortality is slightly more pronounced than in women, accounting for 10-30 percent of the gender gap in European countries.

McCartney *et al.* (2011) demonstrate that smoking accounts for 40-60 percent of the mortality difference by gender in European countries. In our study the variable smoking is not statistically significant, which is consistent with the work developed by Johansson and Sundquist (1999) and Miller and Frech (2000). This result may be due to the fact that there exists a time lag between smoking and the development of health problems (lung and other types of cancer, emphysema and other chronic lung diseases), which implies that the full long-run consequences of smoking at the aggregate level are probably not yet visible.

The variable proportion of total healthcare expenditure financed by the government measures government intervention in the healthcare sector. The intervention of the government in the health sector can have either a beneficial or negative impact on the sector. By financing healthcare services, the government may enable individuals to access healthcare services, who otherwise would not have access to such services without the government intervention. However, the government intervention can be done at the cost of excessive regulation (setting maximum prices and defining wages, for example) which may affect the quantity and quality of the services provided in the health sector, affecting in this way the health status of the population (Santerre *et al.*, 1991). According to Ahlbrandt (1973), Brennan and Buchanan (1980), and Stigler (1971) excessive government intervention in the healthcare sector has negative, rather than beneficial, consequences on the total performance of the healthcare sector. In the work developed by Or (2001), public intervention in the healthcare sector has a negative and significant coefficient for men, which means that this variable does not appear to have a significant role in explaining the reduction of premature mortality.

To capture the efficiency of home healthcare, we use as a *proxy* for education level the amount of public spending on education as percentage of GDP due to the unavailability of more direct measures of educational attainment. The different impact of education on both genders can be due to biological differences. Men and women may achieve similar educational outcomes, given the same inputs, but because of biological differences, the same healthcare inputs may result in very different health outcomes.

Different authors have studied the effect of education on health over the years. Grossman (1972a, 1972b and 1976), Berger and Leigh (1989), and Leigh (1983) tested and validated the hypothesis that schooling increases the efficiency of household health production. This is possible because schooling improves the knowledge of the relationship between health behaviors and health outcomes, leading people to choose healthy behaviors and use healthcare resources more efficiently. People with a higher education level are less likely to smoke and drink and more likely to exercise. Education not only improves health directly (through more healthy lifestyles) but also indirectly through work and economic conditions (Ross and Wu, 1995).

According to Ricci and Zachariadis (2008) when the average patient is more educated the probability of physicians adopting and implementing new treatments is higher since these individuals are more receptive to new medical knowledge. Generally education is directly linked with health literacy. "Health literacy implies the achievement of a level of knowledge, personal skills and confidence to take action to improve personal and community health by changing personal lifestyles and living conditions. Thus, health literacy means more than being able to read pamphlets and make appointments. By improving people's access to health information, and their capacity to use it effectively, health literacy is critical to empowerment. Health literacy is itself dependent upon more general levels of literacy. Poor literacy can affect people's health directly by limiting their personal, social and cultural development, as well as hindering the development of health literacy" WHO (1998).

However, according to our results, education is not a statistically significant determinant of health status for women, but is for men. The positive impact of education on

health status of the population is shown in Siddiqui and Mahmood (1994). In turn, Crémieux *et al.* (1999) and Grubaugh and Santerre (1994) have found little empirical support for the relationship between education and health indicators.

Other variables were tested such as sugar consumption (kilos *per capita*); the number of doctor visits *per capita*, the unemployment rate, the number of hospitalizations *per* million population, the number of professionally active physicians *per* million population, pharmaceutical sales *per capita* in US dollars, converted at economy-wide PPP, the proportion of long term care recipients in institutions (other than hospitals) and homes relative to the total population, among others. However, such variables were not statistically significant, which led to their exclusion from the analyses.

An additional analysis was done to test for possible time breaks during the period in question. However, the results obtained did not suggest the existence of any time breaks. Such conclusions might be due to the fact that the variables in the regression already capture endogenously such an effect or because there are not any significant time breaks over the period analyzed. Moreover, we also considered the hypothesis of fixed effects on time that were refuted in the respective significance tests.

4.6.1 Government intervention in the health sector

The fact that governments provide public money to the healthcare sector does not imply that these funds are converted into effective services, due to possible inadequate institutional capacity and to inefficient and inequitable uses of resources. Furthermore, the net effect of public intervention in the healthcare sector depends on the severity of market failures.

In this sense, public spending can encourage the private sector to move away from healthcare market as a result of an increase in public supply (public spending in the health sector may crowd out private spending in primary healthcare, reducing competiton in the healthcare market, which will decrease, according to Culyer *et al.* (1990), the potential gains in efficiency, quality, and consumer choice present in competitive markets):

"*…extending publicly funded health care could merely crowd out the consumption of equally effective private services. Even if the government were to deliver health services effectively, the health impact would depend not on the total use of public services but rather on how public provision affected total use of all services*" (Filmer *et al*, 2000, pp. 214).

Despite public financing of healthcare expenditure providing wider access to healthcare, which may allow the improvement of health outcomes, there is also the possibility that the increase in public financing can lead to less efficient provision of healthcare services and worsen health outcomes (Berger and Messer, 2002).

Generally, public spending in healthcare services can affect health status through four distinct mechanisms: the composition of public spending; the output of the public sector; the net impact of public sector supply on overall consumption; and the health production function (Filmer *et al.*, 2000).

According to some empirical studies about the impact of government intervention on infant mortality or child mortality, public expenditure on health as a share of GDP has no or a small impact on such indicators (Carrin and Politi, 1996; Demery and Walton, 1998; Filmer and Pritchett, 1997; Musgrove, 1996; Santerre *et al*., 1991;). Bidani and Ravallion (1997) find a relatively small effect of public spending on aggregate health status (of the poor and non-poor taken together). Berger and Messer (2002) found a positive and significant association between the share of healthcare spending financed by the government and mortality.

Although some people argue that there should be more public spending on primary healthcare, there exists little evidence on the beneficial impact of such spending on health indicators. As previously mentioned, some authors argue that this is because greater government intervention in the health sector may come at the cost of unnecessary regulation, being more likely to have an adverse impact rather than a beneficial impact on the performance of the healthcare sector (Ahlbrandt 1973; Brennan and Buchanan 1980; Stigler 1971). Many studies done in other areas of the economy (the transportation sector, education, postal system) show that governmental intervention and regulation can affect total output (quantity and quality) (Baumol, 1989).

4.6.2 Technological Composite Index

> "*I am going to talk about a particular chapter in the history of disease, a chapter characterized by the surprising fact that the net effect of successful technical innovations used in disease control has been to raise the prevalence of certain diseases and disabilities by prolonging their average duration.*"
>
> Gruenberg (1977, pp. 3)

Technological progress in the healthcare sector makes it possible to avoid the death of some patients by curing certain previously fatal pathologies, increasing the survival rate and consequently the number of chronically ill people. In this way, some technological advances in healthcare did not arise to prevent or cure diseases, but to keep people alive, which is the case of organ transplantation, radiotherapy and chemotherapy (Kumar and Ozdamar, 2004).

With the aim of evaluating the impact of technological innovation in life expectancy adjusted by perceived health status, we decided to construct a technological composite index able to reflect the technological level of the countries in the healthcare sector.

The indicators used in the construction of the composite index have been collected from the OECD database, according to available data. The methodology behind the construction of each variable was based on the work by Nardo *et al*. (2005), in which the weights of different indicators were computed using factor analysis.

In Appendix B Table B.9, we list the indicators, which constitute the present index with their respective weights. This index has two main groups of variables: group one (MRI, MAM, RTE, LITH and MRIE) corresponds to healthcare machinery available in the country, while group two (END, FUKIDNEY, BONE, HEART, LIVER, LUNG and

KIDNEY) represents the most innovative medical procedures over the past few years. By incorporating these two groups we want to replicate, in the composite index, the treatment substitution effect and the treatment expansion effect presented by Cutler and McClellan (2001).

From Table 4.7 we can see that technological innovation contributes negatively to life expectancy adjusted by the perceived health status. Initially we considered this result a little strange. However, after some additional research we came across what Gruenberg (1977) calls "the failure of success".

According to Gruenberg (1977, pp. 781) medical research instead of improving life and reducing diseases, "*it produced tools which prolong diseases, diminished lives and so increase the proportion of people who have a disabling or chronic disease. That is a major but unintended effect of many technical improvements stemming from health research. These increasingly common chronic conditions represent the failures of success. Their growing prevalence and longer duration are a product of progress in health technology*."

In this sense, our result confirms in part the following statement "…*the techniques we have to improve life expectation perpetuate sick lives more than they do healthy lives*..." (Gruenberg, 1977, pp. 794). To confirm completely the theory defended by Gruenberg (1977) we have to analyze the effect of our technological composite index on life expectancy.

Using the same sample and the same explanatory variables used in the estimation of life expectancy adjusted by perceived health status, we estimated a new regression using this time life expectancy as a dependent variable, in order to ascertain the effect of technological innovation on life expectancy. In Table 4.7 we present the estimated coefficients for the composite technological index and for the composite technological index to the power of the square (the other estimated coefficients of the regression may be consulted in Annex B, Table B.10).

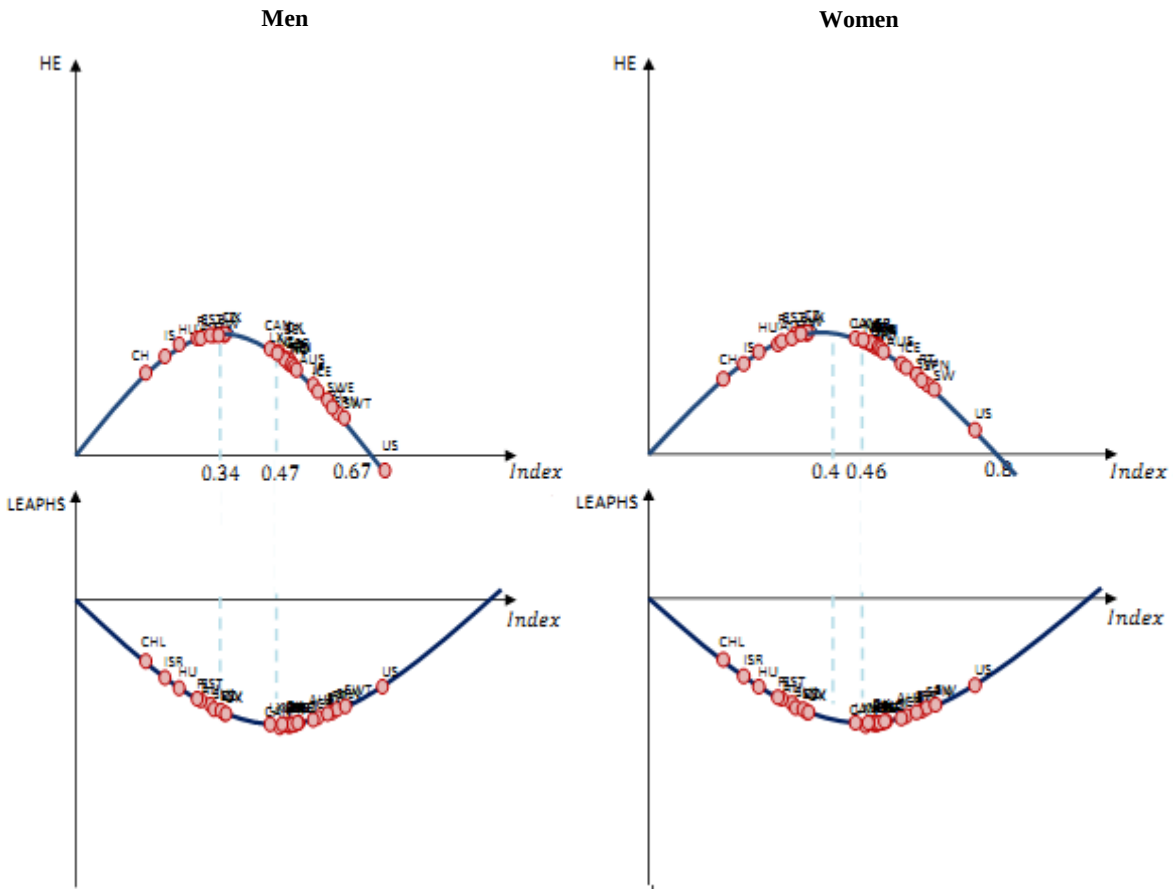
Table 4.7. Effect of technological composite index on life expectancy

	INDEX	INDEXSQ
Men	1.44872[b]	-2.150789[a]
Women	4.650939[a]	-5.882433[a]

Note: According to this, the technological composite index (INDEX) has a positive effect on life expectancy, that is, an increase in INDEX will lead to an increase in life expectancy. a, b represent 1% and 5% levels of significance.

As it is possible to see, technological innovation has a positive and significant effect on life expectancy in both genders, which together with the previous results supports the hypotheses developed by Gruenberg (1977). In order to analyze in more detail the two effects we decided to construct the graphs in Figure 4.7.

Figure 4.7. The effect of the technological composite index on LEAPHS and health expectancy



Note:.Countries on the left side of 0.34 for health expectancy and LEAPHS: Chile; Israel; Hungary and Poland.
Countries between 0.34 and 0.47: Estonia; Slovakia; Ireland; Australia; UK; Slovenia; Czech Republic; Luxembourg and Canada.
Countries on the right side of 0.47: New Zealand; Japan; Germany; Denmark; Netherland; France; Finland; Italy; Belgium; Norway; Austria; Iceland; Sweden; Portugal; Spain; Switzerland and USA.

Note: Countries on the left side of 0.4 for health expectancy and LEAPHS: Chile; Israel; Hungary; Poland; Estonia; Slovakia; Ireland; Australia; UK and Slovenia. Countries between 0.4 and 0.46: Luxembourg and Czech Republic. Countries on the right side of 0.46: Canada; New Zealand; Japan; Germany; Denmark; Netherland; France; Finland; Italy; Belgium; Norway; Austria; Iceland; Sweden; Portugal; Spain; Switzerland and USA.

Analyzing in more detail these graphs it is possible to conclude that:

- For men (women), between the values 0 and 0.34 (0.4), more investment in health technologies will lead simultaneously to increases in life expectancy and decreases in LEAPHS. That is, increases in the technological level will only increase the number of years with disability – "*extension of life…also…an extension of disease and disability*" (Gruenberg, 1977, pp. 5). This conclusion is in accordance with the theory developed by Gruenberg (1977) due to the fact that the countries, which currently are located to the right side of 0.34 (0.4) for men (women), were in this interval in the 60's and 70's.
- From 0.34 (0.4) additional technological investment will begin to cancel out the positive effects of past technological investments in health expectancy, reaching its limit for index values greater than 0.67 (0.8) for men (women).
- Starting from 0.47 (0.46) there is a positive contribution of technological innovation in LEAPHS but negative in life expectancy for men (women). In this case, the new technologies help to increase LEAPHS, reducing the years of life with disability.
- According to these figures and the increases seen in life expectancy over the last years, it is possible to conclude that, in the countries on the right hand side of 0.34 (0.4) there are other determinants that contribute positively to life expectancy, such as changes in lifestyles, diet, medical prevention, and economic growth.
- In these graphs it is also possible to note that the UK seems to be relatively less technologically developed than other countries in the health sector. This result is consistent with Boyle (2011, pp. 185) "*...the United Kingdom has had relatively few CT scanners and MRI units per head of population compared with other OECD countries*".

The differences between the two graphs are essentially due to health differences between genders. While men generally suffer from diseases that shorten life, the disease pattern in women leads to many women living in sickness or illness conditions (Altman and Bernstein, 2008), which leads to a greater demand for healthcare services by women. This happens essentially due to biological risks; risks acquired through social roles; lifestyle and illness behaviors (Case and Paxson, 2005; Waldron, 1985; Wingard, 1984).

In addition, the graphs show that, initially the countries began to invest essentially in means of diagnosis, which has no impact on the quality of a patient's life. In this phase, the diagnosis and treatment of diseases is more important than the treatment of the sick. This phase is characterized by increases in the number of Computed Tomography Scanners; Positron Emission Tomography scanners, Magnetic Resonance Imaging; Digital Subtraction Angiography and Life Support Machines.

Additionally the nature of health problems has changed. Nowadays, chronic diseases are more frequent (for example: diabetes, obesity, and cholesterol) affecting not only the adult population but also children and the elderly.

Over time, countries began to invest more in technologies and procedures that take into account not only treatment of diseased but also the prevention of diseases and the quality of patients' lives. This became possible through the development of genetics, nanotechnology and robotics, which allowed the development of non-invasive and low invasive medical devices. Some of these developments have the potential to prolong and improve lives. Such technologies that have improved quality of life have included the pacemaker; insulin pen; human papilloma virus vaccine; natural orifice surgery; Ventricular Assist Device, human genome mapping, etc.

The decline in the mortality rate over the years gives more importance to chronic diseases and their consequences (for example: the productivity reduction; prolonged disability; the need for care and finally death). In this way, some countries decided to develop integrated long-term care (convalescent care, recovery and reintegration of chronically ill patients and people in situations of dependency) with the aim of increasing the quality of life of patients with such diseases.

There is also a greater concern for investing in medical procedures and technologies focused essentially on improving a patient's quality of life instead of investing in technologies directed to prolonging a patient's life. Examples of this are cataract operations and prostheses.

4.7 Conclusion

The aims of this paper were to determine if the concern surrounding healthcare expenditure is legitimate by evaluating the return of such spending in quantitative (life expectancy) and qualitative (morbidity and disability) terms.

Due to several problems inherent to the data - its specificity, its short time dimension, and the rare country coverage of some healthcare outcomes measures, we decided to construct a new health status indicator that combines mortality and morbidity, through the adjustment of life expectancy to the quality of years lived – LEAPHS.

Using a panel data set of thirty OECD countries from 1980 to 2011, we estimated how various socio-economic, environment, lifestyle and technological factors affect this health status indicator. Through this analysis we found several interesting results.

Almost all the variables considered were found to be significant and consistent with the existing literature despite the health outcome measure used being different. Among the significant variables were total healthcare expenditure *per* capita (Hitiris and Posnett, 1992), GDP *per capita*; the proportion of the urban population; health expenditure financed by the government; and the technological composite index.

The main conclusion that emerges from this study is that the concern around the amount of healthcare expenditure *per capita* should not be focused on the total expenditure *per se*, but instead directed to the amount financed by the government.

Other important conclusions are related to the technological composite index. According to our results, most health technologies used until now serve mainly to prolong sick lives instead of to ensure a healthy life: "…*the techniques we have to improve life expectation perpetuate sick lives more than they do healthy lives*..." (Gruenberg, 1977, pp. 794). This conclusion may change through the discovery/development of new technologies, medical care services and medical techniques that offer better quality of life to patients, for example through integrated long term care, which may lead to a different configuration in the graphs presented in Figure 4.7.

In addition to these conclusions, the results obtained also confirm that there is a significant potential for public health initiatives such as anti-drinking campaigns and compulsory education to improve health status.

Despite its strengths there are some limitations to this study. For example it was not possible to obtain information about the degree of equity in health status across the population, something important in the definition of healthcare policies. Additionally, existing data about the amount of healthcare expenditure does not allow a detailed analysis of such expenditure, i.e., to know in which areas within the health sector money is being spent. The same concern applies to healthcare spending from the government – we cannot identify which areas within the sector receive financing. It is also important to know how resources are being allocated and not just how much money is being spent.

Another limitation is the impossibility of using other health indicators, due to the lack of time series data and rare country coverage, to compare and validate the results that we obtained.

Annex B

Table B.8. Descriptive statistics

Variable	Mean	St. Deviation	Min	Max
GDP *per capita*	10.10	0.41	9	11.34
Healthcare expenditure *per capita*	7.61	0.54	6.16	8.99
Urban population	4.33	0.14	3.91	4.58
Alcohol consumption	2.26	0.32	0.69	2.88
Tobacco consumption	2.75	0.19	2.09	3.22
Hospital beds	1.7	0.43	0.83	2.75
Health expenditure financed by Government	4.28	0.18	3.66	4.56
Health and social employment	3.75	0.45	2.48	4.76
Public spending on education	1.68	0.2	1.11	2.17
Fat intake	4.88	0.18	4.21	5.14
INDEX	0.39	0.07	0.25	0.53
LEAPHS Men	57.59	8.81	12.55	92.34
LEAPHS Women	57.02	9.16	32.64	73.19

Note: This table presents the descriptive statistics of the explanatory variables and of LEAPHS.

Table B.9. Composition of the technological composite index

Variables	Description	Weight
MRI	Magnetic Resonance Imaging units, total – *Per* million population.	0.0938
MAM	Mammography, total – *Per* million population.	0.0983
RTE	Radiation therapy equipment, total – *Per* million population.	0.1202
LITH	Lithotripters, total – *Per* million population.	0.0483
MRIE	Magnetic Resonance Imaging exams, total – *Per* million population.	0.1085
END	End-stage renal failure patients – *Per* 100.000 population.	0.0947
FUKIDNEY	Functioning kidney transplants – *Per* 100.000 population.	0.1103
BONE	Bone marrow transplants – *Per* 100.000 population.	0.0454
HEART	Heart transplants – *Per* 100.000 population.	0.0597
LIVER	Liver transplants – *Per* 100.000 population.	0.0602
LUNG	Lung transplants – *Per* 100.000 population.	0.0733
KIDNEY	Kidney transplants – *Per* 100.000 population.	0.0872

Notes: This table displays the variable names, definitions and respective weights of the variables that constitute the technological composite index.

Table B.10. Estimated coefficients for health expectancy

Variables	Women	Men
GDP *per capita*	0.33	1.1[a]
Healthcare expenditure *per capita*	-0.43[c]	-0.46[c]
Hospital beds	0.18	-0.06
Public spending on education	0.22	0.39[a]
Urban population	-3.45[a]	-2.3[a]
Health expenditure financed by General Government	0.33	-0.23
Alcohol consumption	-0.65[a]	-0.96[a]
Health and social employment	-0.2	-0.89
Tobacco consumption	0.3[a]	0.37[b]
Fat intake	-0.55[c]	-0.76[c]
INDEX	4.65[a]	1.45[b]
INDEXSQ	-5.88[a]	-2.15[a]
CONS	92.3[a]	80.98[a]

Note: In this table we present the coefficients of the regression used to determine the impact of technological composite índex on health expectancy.

Chapter 5

5. General Conclusion

5.1 Conclusion

Throughout the previous chapters we have discussed different topics related to the field of Health Economics, namely (i) the origin of the field and the works of its leading authors, (ii) the measurement of health care costs, and (iii) the impact of these increased costs on population health. Furthermore, our analysis concluded that several main factors over the last few decades have contributed to an increase in healthcare spending, focusing especially on the impact of technological innovation in the healthcare sector.

In the final chapter we tried to assess if the present concern surrounding rampant healthcare expenditure growth is really legitimate, while also evaluating and measuring the return of such expenditures in quantitative (life expectancy) and qualitative (morbidity and disability) terms. To accomplish this, we constructed a new health status indicator able to consolidate mortality and morbidity into a single composite measure. The main conclusion that emerged is that the concern should not be focused on the total healthcare per capita expenditure *per se*, but rather instead directed to the amount financed by the government. Our results suggest that it is important for the countries analyzed in our sample to reconsider the proportion of their health care expenditures that are publicly financed.

With respect to the determinants of healthcare expenditure, many of our conclusions reinforced findings that were also found in the previous literature, such as in papers by Barros (1998) and Okunade *et al*. (2004). Yet, several other results regarding the influence of technology were novel. In addition, we showed that technological innovation has a differential positive impact on costs depending on a country's stage of development of technology, i.e. increases in the health expenditure *per capita* driven by technological innovation exhibited diminishing returns.

Ultimately, these results allow us to conclude that ever-increasing investments into technological innovation can efficiently and effectively save resources. Despite the initial effort of required investment, additional investments are susceptible to being offset from efficiency gains through the use of technology. This fact may potentially lead to an increase

in global divergence or inequity between countries with respect to technological level in the healthcare sector. For example, countries with lower technological levels in healthcare (such as Mexico) do not benefit from the resource savings that countries with a higher technological level (such as the USA or Switzerland) benefit from. Thus, countries with higher technological levels will be open to investing in technological innovation, given the greater marginal benefit they receive. This fact may also be exacerbated by an inherent weak capacity of certain countries, particularly those with lower technological levels, to invest in more technologies due to the initial costs that it entails.

Amongst our other notable results in the study, most health technologies used until now serve mainly to prolong life instead of to ensure a healthy life: "…*the techniques we have to improve life expectation perpetuate sick lives more than they do healthy lives*..." (Gruenberg, 1977, pp. 794). This conclusion may change with the discovery/development of new technologies, medical care services and medical techniques that offer better quality of life to the patients, for example through integrated long term care.

However, it is important to point out that despite several strengths, there are some limitations to this study. For example it was not possible to obtain information about the degree of equity in health status across the population, something important in the definition of healthcare policies. Moreover, the existent data about the amount of healthcare expenditure does not allow a detailed analysis of such expenditure, i.e., an analysis of where within the health sector money is being spent. This same concern applies to healthcare spending from the Government – we cannot identify which areas within the sector receive financing. Presently, it is easier to understand how much money is being spent in the health industry as opposed to how the resources are being spent.

The inability to consider ICTs in the technological composite index was another limitation of this study. This occurred due to the inexistence of certain variables that were able to reflect the use of the information and communication technologies in the healthcare sector. Also, the impossibility of using others health indicators, due to their lack of time series data and rare country coverage, made it difficult to compare and validate the results that we obtained.

Despite these and other limitations inherent in international comparisons, we cannot forget that, these kinds of limitations do not prevent individual governments from defining health policies or/and the amount of healthcare spending based largely on some healthcare outcomes measures such as infant mortality and life expectancy.

Bibliography

Aaron, J. (1991), *Serious and Unstable Condition: Financing America's Healthcare*, The Brookings Institution, Washington, DC.

Aaron, J. (2002), "The Unsurprising Surprise of Renewed Healthcare Cost Inflation", *Health Affairs*, http://content.healthaffairs.org/content/early/2002/02/23/hlthaff.w2.85.full.pdf+html, retrieved November 22, 2011.

Abel-Smith, B. (1967), "An International Study of Health Expenditure", *Public Health Papers*, Nº 32, Geneva: World Health Organization.

Afonso, A. and M. St. Aubyn (2005), "Non-parametric Approaches to Education and Health Efficiency in OECD Countries", *Journal* of *Applied Economics* Vol. 8, Nº 2, pp. 227-246.

Afonso, A. and M. St. Aubyn (2006), "Relative Efficiency of Health Provision: a DEA Approach with Non-discretionary Inputs", ISEG-UTL Economics Working Paper, Nº. 33/2006/DE/UECE, www.iseg.utl.pt/departamentos/economia/wp/wp332006deuece.pdf, retrieved November 08, 2012.

Ahlbrandt, R. Jr. (1973), "Efficiency in the Provision of Fire Service", *Public Choice*, Vol. 16, Nº 1, pp. 1-15.

Alexopoulos, E. C. and M. Geitona (2009), "Self-Rated Health: Inequalities and Potential Determinants", *International Journal of Environmental Research and Public Health*, Vol. 6, Nº 9, pp. 2456-2469.

Allison, P. D. (2000), *Missing data*, Thousand Oaks, CA: Sage Publications.

Altman, B. and A. Bernstein (2008), "Disability and Health in the United States, 2001–2005", Hyattsville, MD: National Center for Health Statistics.

Ambler, G., R. Z. Omar and P. A. Royston (2007), "A Comparison of Imputation Techniques for Handling Missing Predictor Values in a Risk Model with a Binary Outcome", *Statistical Methods in Medical Research*, Vol. 16, Nº 3, pp. 277-298.

Andersen, R. and L. Benham (1970), "Factors Affecting the Relationship between Family Income and Medical Care Consumption", in Empirical Studies in Health Economics. H. Klarman (editor), John Hopkins University Press, Baltimore and London.

Anupam, B. J. and T. Philipson (2007), "Cost-Effectiveness as a Price Control", *Health Affairs*, Vol. 26, Nº 3, pp. 696-703.

Arnold, A. M. and R. A. Kronmal (2003), "Multiple Imputation of Baseline Data in the Cardiovascular Health Study", *American Journal of Epidemiology*, Vol. 157, Nº 1, pp. 74-84.

Arrow, K. J. (1963), "Uncertainty and the Welfare Economics of Medical Care", *American Economic Review*, Vol. 53, Nº 5, pp. 941-973.

Auster, R., I. Levenson and D. Sarachek (1969), "The Production of Health: An Exploratory Study", *The Journal of Human Resources*, Vol. 4, Nº 4, pp. 411-436.

Babazono, A. and A. L. Hillman (1994), "A Comparison of International Health Outcomes and Health Care Spending", *International Journal of Technology Assessment in Health Care*, Vol. 10, Nº 3, pp. 376-381.

Baker, L. and S. K. Wheeler (1998), "Managed Care and Technology Diffusion the Case of MRI", *Health Affairs*, Vol. 17, Nº 5, pp. 195-207.

Banins, M. (2003), "Projecting Future Needs. Long-term Projections of Public Expenditure on Health and Long-term Care for EU Member States", in A Disease-based Comparison of Health Systems. What is best at what cost?, OECD (editor), Chapter 9, OECD: Paris.

Barlow, R. and B. Vissandjee (1999), "Determinants of National Life Expectancy", *Canadian Journal of Development Studies*, Vol. 20, Nº 1, pp. 9-28.

Barros, P. P. (1998), "The Black Box of Healthcare Expenditure Growth Determinants", *Health Economics*, Vol. 7, pp. 533-544.

Barros, P. P. (2009), *Economia da Saúde – conceitos e comportamentos*, Coimbra: Edições Almedina.

Baumol, W. J. (1989), "Containing Medical Costs: Why Price Controls Won't Work", Public Interest, Vol. 93, pp. 37-53.

Berger, M. and J. Leigh (1989), "Schooling, Self-selection, and Health", *Journal of Human Resources*, Vol. 24, Nº 3, pp. 433-55.

Berger, M. and J. Messer (2002), "Public Financing of Health Expenditure, Insurance, and Health Outcomes", *Applied Economics*, Vol. 34, Nº 17, pp. 2105-2113.

Bhat, V. N. (2005), "Institutional Arrangements and Efficiency of Health Care Delivery Systems", *European Journal of Health Economics*, Vol. 6, Nº 3, pp. 215-222.

Bidani, B. and M. Ravallion (1997), "Decomposing Social Indicators Using Distributional Data", *Journal of Econometrics*, Vol. 77, Nº 1, pp. 125-139.

Blomqvist, A. G. and R. A. L. Carter (1997), "Is Health Care Really a Luxury?", *Journal of Health Economics*, Elsevier, Vol. 16, Nº 2, pp. 207-229.

Blume, S. B. (1991), "Sexuality and Stigma: the alcoholic Woman", *Alcohol Health & Research World*, Vol. 15, Nº 2, pp. 139-146.

Bodenheimer, T. (2005), "High and Rising Healthcare Costs. Part 1: Seeking an Explanation", *Annals of Internal Medicine*, Vol. 142, Nº 10, pp. 847-854.

Boyle. S. (2011), "Health System Review", Health Systems in Transition, Vol. 13, Nº 1, pp. 1-486.

Brailer, D. (2008), *Digital Medicine in the Era of Health Reform*. Presented at the seminar entitled Patient-Centered Computing and eHealth: Transforming Healthcare Quality, Boston, MA.

Brennan, G. and J. M. Buchanan (1980), *The Power to Tax: Analytical Foundations of a Fiscal Constitution*, New York: Cambridge University Press.

Breyer, F. and S. Felder (2006), "Life Expectancy and Healthcare Expenditures: A new Calculation for Germany using the Costs of Dying", *Health Policy*, Vol. 75, Nº 2, pp. 178-86.

Brockman, H. (2002), "Why is Less Money Spent on Healthcare for the Elderly than for the Rest of the Population? Healthcare Rationing in German Hospitals", *Social Science and Medicine*, Vol. 55, Nº 4, pp. 593-608.

Capik, C. and Z. Bahar (2008), "Determination of Factors Influencing Perceived Health Status Among Poor and Non-poor Women in Eastern Turkey, *International Journal of Caring Sciences*, Vol. 1, Nº 2, pp. 58-65.

Cardoso, C. (2008), "Health Economics or Healthcare Economics?", *Tékhne – Polytechnical Studies Review*, Vol. 6, Nº 10, pp. 189-198.

Carrilho, M. J. and L. Patrício (2004), "Tábuas de Mortalidade em Portugal", *Revista de Estudos Demográficos*, Nº 36, INE.

Carrin, G. and C. Politi (1996), "Exploring the Health Impact of Economic Growth, Poverty Reduction, and Public Health Expenditure", Tijdschrift voor economie en management, Vol. 40, Nº 3, pp. 227-246.

Case, A. and C. Paxson (2005), "Sex Differences in Morbidity and Mortality", Demography, Vol. 42, Nº 2, pp. 189-214

Chaudhry, B., J. Wang, S. Wu, M. Maglione, W. Mojica, E. Roth, S. C. Morton and P. G. Shekelle (2006), "Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care", *Annuals of Internal Medicine*, Vol. 144, Nº 10, pp. 742-752.

Bibliography

Christiansen, T., M. Bech, L. Lauridsen and P. Nielsen (2006), "Demographic Changes and Aggregate Healthcare Expenditure", in Europe, ENEPRI Research Report Nº 32.

Clark. T. G. and D. G. Altman (2003), "Developing a Prognostic Model in the Presence of Missing Data: an Ovarian Cancer Case Study", *Journal of Clinical Epidemiology*, Vol. 56, Nº 1, pp. 29-37.

Clogg, C. C., D. B. Rubin, N. Schenker, B. Schultz and L. Weidman (1991), "Multiple Imputation of Industry and Occupation Codes in Census Public-use Samples using Bayesian Logistic Regression (in applications and case studies)", *Journal of the American Statistical Association*, Vol. 86, Nº 413, pp. 68-78.

Cochrane, A. L., A. S. St. Ledger and F. Moore (1978), "Health Service "Input" and Mortality "output" in Developed Countries", *Journal Epidemiology and Community Health*, Vol. 51, Nº 4, pp. 344-348.

Congressional Budget Office (CBO) (2008), "Technological Change and the Growth of Healthcare Spending", Washington, DC, Nº 2764.

Cox, C. L., M. Spiro and J. A. Sullivan (1988), "Social Risk Factors: Impact on Elders' Perceived Health Status", *Journal of Community Health Nursing*, Vol. 5, Nº 1, pp. 59-73.

Crémieux P. Y., M. C. Mieilleur, P. Ouellette, P. Petit, P. Zelder, and K. Potvin (2005), "Public and Private Pharmaceutical Spending as Determinants of Health Outcomes in Canada", *Health Economics*, Vol. 14, Nº 2, pp. 107-116.

Crémieux, P. Y., P. Ouellette and C. Pilon (1999), "Health Care Spending as Determinants of Health Outcomes", *Health Econonomics*, Vol. 8, Nº 7, pp. 627-639.

Culyer, A. J, A. Maynard and J. Posnett (1990), *Competition in Health Care: Reforming the National Health Service*, London: Macmillan Press.

Culyer, A. J. (1988), "Health Expenditures in Canada: Myth and Reality; Past and Future", *Canadian Tax Paper*, Nº 82, Canadian Tax Foundation, Toronto.

Culyer, A. J. (1989), "Cost Containment in Europe", *Healthcare Financing Review,* Annual Supplement, pp. 21–32.

Cutler, D. M. (1995), "Technology, Health Costs, and the NIH", National Institutes of Health Roundtable on the Economics of Biomedical Research.

Cutler, D. M., and M. McClellan (1996), "The Determinants of Technological Change in Heart Attack Treatment", NBER Working Paper, Nº 5751.

Cutler, D. M., and M. McClellan (2001), "Is Technological Change in Medicine Worth it?" *Health Affairs*, Vol. 20, Nº 5, pp. 11-29.

Davies, A. R. and J. E. Ware (1981), *Measuring Health Perceptions in the Health Insurance Experiment*, Santa Monica, CA: Rand Corporation.

Demery, L. and M. Walton (1998), *Are Poverty Redution and Other 21st Century Social Goals Attainable?*, Washington: World Bank.

Di Matteo, L. (2003), "The Income Elasticity of Healthcare Spending: A Comparison of Parametric and Nonparametric Approaches", *European Journal of Health Economics*, Vol. 4, Nº 1, pp. 20-29.

Docteur, E. and H. Oxley (2003), "Healthcare Systems: Lessons from the Reform Experience", OECD Health Working Papers. Organisation for Economic Co-operation and Development, Paris, France.

Dolan, P., C. Gudex, P. Kind and A. Williams (1995) "A Social Tariff for EuroQol: Results from a UK General Population Survey", Nº 138chedp, Working Papers, Centre for Health Economics, University of York.

Economou, C. and C. Giorno (2009), "Improving the Performance of the Public Health Care System in Greece", OECD Economics Department Working Papers, Nº 722.

Edwards, F. H., E. D. Peterson, L. P. Coombs, E. R. Delong, W. R. Jamieson, A. L Shroyer and F. L. Grover (2001), "Prediction of Operative Mortality after Valve

Replacement Surgery", *Journal of the American College of Cardiology*, Vol. 37, Nº 3, pp. 885-892.

Edwards, R. T. (2001), "Paradigms and Research Programmes: is it Time to Move from Healthcare Economics to Health Economics?" *Health Economics*, Vol. 10, Nº 7, pp. 635-649.

Elola J., A. Daponte and N. Vicente (1995), "Health Indicators and the Organization of Health Care Systems in Western Europe", *American Journal of Public Health*, Vol. 85, Nº 10, pp. 1397-1401.

European Commission (2004), "E-Health – Making Healthcare Better for European Citizens: An Action Plan for a European e-Health Area", Brussels.

European Commission (2010), *Health Trends in the EU*. European Commission, Directorate-General "Employment, Social Affairs and Equal Opportunities", Unit E1 – Social and Demographic Analysis.

European Health Expectancy Monitoring Unit (EHEMU) (2012), *Country Reports*, Issue 5 – April 2012, Health Expectancy in Portugal, http://www.eurohex.eu/pdf/CountryReports_Issue5/Portugal_Issue%205.pdf, retrieved November 08, 2012.

Euroqol (2013), http://www.euroqol.org/home.html, accessed in January 2013.

Felder, S., M. Meier and H. Schmitt (2000), "Healthcare Expenditure in the Last Month of Life", *Journal of Health Economics*, Vol. 19, Nº 5, pp. 679-695.

Feldstein, M. (1971), The Rising Costs of Hospital Care, National Center for Health Services Research and Development Information Resources Press, Washington, D.C.

Filmer, D. and L. Pritchett (1997), "Child Mortality and Public Spending on Health: How Much does Money Matter?", Policy research working paper Nº 1864, Washington: World Bank. www.worldbank.org/html/dec/Publications/Workpapers/WPS1800series/wps1864/wps1864.pdf, retrieved September 23, 2012.

Filmer, D. and L. Pritchett (1999), "The Impact of Public Spending on Health: Does Money Matter?" Social Science and Medicine, Vol. 49, Nº 1, pp. 1309-1323.

Filmer, D., J. S. Hammer and L. H. Pritchett (2000), "Weak Links in the Chain: A Diagnosis of Health Policy in Poor Countries", *The World Bank Research Observer*, Vol. 15, Nº 2, pp. 199-224.

Freeland, M. S. and C. E. Schendler (1983), "National Health Expenditure Growth in the 1980's: an Aging Population, New Technologies, and Increasing Competition", *Healthcare Finance Review*, Vol. 4, Nº 3, pp. 1-58.

Freeman, D. G. (2003), "Is Healthcare a Necessity Or a Luxury? Pooled Estimates of Income Elasticity From US State-Level Data", *Applied Economics*, Vol. 35, Nº 5, pp. 495-502.

Fuchs, V. R. (1972), *Essays in the Economics of Health and Medical Care*, UMI.

Fuchs, V. R. (2000),"The Future of Health Economics", *Journal of Health Economics*, Vol. 19, Nº 2, pp. 141-157.

Gerdtham, U. G. and B. Jönsson (2000), "International Comparisons of Health Expenditure: Theory, Data and Econometric Analysis", in Handbook of Health Economics, Volume 1A, A. J. Culyer and J. P. Newhouse (editors), Elsevier, Chapter 1, pp. 11-54.

Gerdtham, U. G., J. Sögaard, F. Andersson and B. Jönsson (1992 b), "A Pooled Cross-Section Analysis of the Health Expenditure of the OECD Countries", in Health Economics Worldwide, P. Zweifel and H. Frech (editors), Dordrecht: Kluwer Academic Publishers.

Gerdtham, U. G., J. Sögaard, F. Andersson and B. Jönsson, (1992 a), "An Econometric Analysis of Health Expenditure: a Cross-Sectional Study of the OECD Countries", *Journal of Health Economics*, Vol. 11, Nº 1, pp. 63–84.

Gerdtham, U.G. and M. Lothgren (2000), "On Stationarity and Cointegration of International Health Expenditure and GDP", *Journal of Health Economics,* Vol. 19, Nº 4, pp. 461-475.

Gerdtham, U.G., B. Jönsson, M. MacFarlan and H. Oxley (1998), "The Determinants of Health Expenditure in the OECD Countries: A pooled Data Analyses", Health, The Medical Profession, and Regulation, P. Weifel (editor), Kluwer Academic Publishers, Dordrecht.

Getzen, T.E. (2000), "Healthcare is an Individual Necessity and a National Luxury: Applying Multilevel Decision Models to the Analysis of Healthcare Expenditures", *Journal of Health Economics,* Vol.19, Nº 2, pp. 259-270.

Gilks, W. R, S. Richardson, and D. J. Spiegelhalter (1996), *Markov Chain Monte Carlo in practice,* London: Chapman & Hall.

Ginsburg, P. B. (2008), "High and Rising Healthcare Costs: Demystifying U.S. Healthcare Spending", *Research Synthesis Report,* Nº 16.

Goddeeris, J. H. (1984 a), "Medical Insurance, Technological Change, and Welfare", Economic Inquiry, Vol. 22, Nº 1, pp. 56-67.

Goddeeris, J. H. (1984 b), "Insurance and Incentives for Innovation in Medical Care", *Southern Economic Journal,* Vol. 51, Nº 2, pp. 530-539.

Gomberg, E. L. (1988), "Alcoholic Women in Treatment: The Question of Stigma and Age", *Alcohol and Alcoholism,* Vol. 23, Nº 6, pp. 507-514.

Graham, J. W., A. E. Olchowski and T. D. Gilreath (2007), "How Many Imputations Are Really Needed? Some Practical Clarifications of Multiple Imputation Theory", *Preventative Science,* Vol. 8, Nº 3, pp. 208-213.

Grossman, M. (1972 a), "On the Concept of Health Capital and the Demand for Health", *Journal of Political Economy,* Vol. 80, Nº 2, pp. 223-255.

Grossman, M. (1972 b), *The Demand for Health: A Theoretical and Empirical Investigation*, New York: Columbia University Press (for the National Bureau for Economic Research).

Grossman, M. (1976), "The Correlation between Health and Schooling", in Household Production and Consumption, Nestor E. Terleckyj (editor), New York: Columbia Univ. Press.

Grubaugh, S. G. and R. E. Santerre (1994), "Comparing the Performance of Health-care Systems: an Alternative Approach", Southern Economic Journal, Vol. 60, Nº 4, pp. 1030-1042.

Gruenberg, E. M. (1977), "The Failure of Success", *The Milbank Memorial Fund Quarterly*, Vol. 55, Nº. 1, pp. 3-24.

Haber, L. D. (1967), "Identifying the Disabled: Concepts and Methods in the Measurement of Disability", Social Security Bulletin Nº 30, pp. 17-34.

Hadley, J. (1982), *More Medical Care, Better Health?*, Urban Institute: Washington, DC.

Haitovsky, Y. (1968), "Missing Data in Regression Analysis" *Journal of the Royal Statistical Society*, Series B, Nº 30, Nº 1, pp. 67-82.

Hall, R. E. and I. J. Charles (2007), "The Value of Life and the Rise in Health Spending", *The Quarterly Journal of Economics*, Vol. 122, Nº 1, pp. 39-72.

Haux, R. (2006), "Health Information Systems – Past, Present, Future", *International Journal of Medical Informatics*, Vol. 75, Nº 3-4, pp. 268-281.

Hill, J. W. and P. Powell (2009), "The National Healthcare Crisis: Is eHealth a Key Solution?" *Business Horizons*, Vol. 52, Nº 3, pp. 265-277.

Hill, J. W., A. W. Langvardt and A. P. Massey (2007), "Law, Information Technology, and Medical Errors: Toward a National Healthcare Information Network

Approach to Improving Patient Care and Reducing Medical Malpractice Costs", *Journal of Law, Technology & Policy,* Vol. 2, pp. 1-79.

Hillestad, R., J. Bigelow, A. Bower, F. Girosi, R. Meili, R. Scoville and R. Taylor (2005), "Can Electronic Medical Record Systems Transform Healthcare? Potential Health Benefits, Savings, and Costs", *Health Affairs*, Vol. 25, Nº 5, pp. 1103-1117.

Hitiris, T. and J. Possnett (1992), "The Determinants and Effects of Health Expenditure in Developed Countries", *Journal of Health Economics*, Vol. 11, Nº 2, pp. 73-101.

Hogan, C., J. Lunney, J. Gabel, and J. Lynn, J. (2001), "Medical Beneficiaries' Costs of Care in the Last Year of Life", *Health Affairs*, Vol. 20, Nº 4, pp. 188-195.

Hoover, D. R., S. Crystal, R. Kumar, U. Samamoorhi and J. C. Cantor (2002), "Medical Expenditure during the Last Year of Life: Findings from the 1992-1996 Medicare Current Beneficiary Survey", *Health Services Research*, Vol. 37, Nº 6, pp. 1625-1642.

Horton, N. J. and K. P. Kleinman (2007), "Much Ado About Nothing: A Comparison of Missing Data Methods and Software to Fit Incomplete Data Regression Models", *The American Statistician*, Vol. 61, No. 1, pp. 79-80.

Huber, M. and E. Orosz (2003), "Health Expenditure Trends in OECD Countries, 1990-2001", *Healthcare Financing Review*, Vol. 25, Nº 1, pp. 1-22.

Huber, P. J. (1964), "Robust Estimation of a Location Parameter", *The Annals of Mathematical Statistics*, Vol. 35, Nº 1, pp. 73-101.

Hunt, S. M., S P. McKenna. J McEwen, E. M. Backett, J. Williams and E. Papp (1980), "A Quantitative Approach to Perceived Health Status: a Validation Study", *Journal Epidemiol Community Health*, Vol. 34, Nº 4, pp. 281-286.

Idler, E. L. and S. Kasl (1991), "Health Perceptions and Survival: Do Global Evaluations of Health Status Really Predict Mortality?" Journal of Gerontology, Vol. 46, Nº 2, pp. 55-65.

Imai, Y. (2002), "Healthcare Reform in Japan", Economics Department Working Paper No. 321, Organisation for Economic Co-operation and Development.

Jagger, C. (1997), *Health Expectancy Calculation by the Sullivan Method: a Practical Guide*, Leicester: Euro-REVES/University of Leicester.

Jemmot, J. B. and S. E. Locke (1984), "Psychological Factors, Immunologic Mediation, and Human Susceptibility to Infectious Diseases: How much do we know?" *Psychological Bulletin*, Vol. 95, Nº 1, pp.78-108.

Jenkinson, C., A. Coulter and L. Wright (1993), "Short Form 36 (SF36) Health Survey Questionnaire: Normative Data for Adults of Working Age", *British Medical Journal*. Vol. 306, Nº 6890, pp. 1437-1440.

Johansson, S. E. and J. Sundquist (1999), "Change in Lifestyle Factors and their Influence on Health Status and all-cause Mortality", *International Journal of Epidemiology*, Vol. 28, Nº 6, pp.1073-1080.

Jönsson, B. (1990), "What Can Americans Learn from Europeans", in Health Care Systems in Transition, OECD (editor), Paris: Organization for Economic Cooperation and Development, pp. 87-101.

Jönsson, B. and I. Eckerlund (2003), "Why do Different Countries Spend Different Amounts on Healthcare? Macroeconomic Analysis of Differences" in Healthcare Expenditure. A Disease-based Comparison of Health Systems. What is Best and at What Cost?, OECD (editor), Chapter 6, pp. 107-119.

Joumard, I., C. André, C. Nicq and O. Chatal (2008), "Health Status Determinants: Lifestyle, Environment, Health Care Resources and Efficiency", OECD Economics Department Working Papers, Nº. 627, OECD, Paris.

Kaleta, D., K. Polariska, E. Dziankowska-Zaborszczyk, W. Hanke, and W. Drygas (2009), "Factors Influencing Self-Perception of Health Status," *Central European Journal of Public Health*, Vol. 17, Nº 3, pp. 122-127.

Kaplan, R. M. and P. Erickson (2000), "Gender Differences in Quality-Adjusted Survival using a Health-Utilities Index", *American Journal of Preventive Medicine*, Vol. 18, Nº 1, pp. 77-82.

Kenkel, D. (1991), "Health Behaviour, Health Knowledge, and Schooling", *Journal of Political Economy*, Vol. 99, Nº 2, pp. 287-305.

Kessler, R. C., R. H. Price and C B. Wortman (1985), "Social Factors in Psychopathology: Stress, Social Support and Coping Processes", *Annual Review of Psychology*, Vol. 36, pp. 531-572.

Khoumbati, K., M. Themistocleous, and Z. Irani (2006), "Evaluating the Adoption of Enterprise Application Integration in Health-Care Organizations", *Journal of Management Information Systems*, Vol. 22, Nº 4, pp. 69-108.

Khuri, S. F., J. Daley, W. Henderson, K. Hur, J O. Gibbs, and G. Barbour (1997), "Risk Adjustment of the Postoperative Mortality Rate for the Comparative Assessment of the Quality of Surgical Care: Results of the National Veterans Affairs Surgical Risk Study", *Journal of the American College of Surgeons*, Vol. 185, Nº 4, pp. 315-327.

Klarman, H. E., D. P. Rice, B. S. Cooper and H. L. Stettler (1970), "Accounting for the Rise in Selected Medical Care Expenditures, 1929-1969", *American Journal of Public Health and the Nation's Health*, Vol. 60, Nº 6, pp. 1023–1039.

Kleiman, E. (1974), "The Determinants of National Outlay on Health", in The Economics of Health and Medical Care, M. Perlman (editor), Macmillan, London and Basingstoke.

Kumar, A. and L. Ozdamar (2004), "International Comparison of Healthcare Systems", *International Journal of Computer, the Internet and Management*, Vol. 12 Nº 13, pp. 81-95.

Lees, D. S. (1961), *Health through choice: An economic study of the British National Health Service*, London: Institute of Economic Affairs.

Lèger, M. (2000), "Health Care of the Future: Vision 2020 Leads the Way – Part 1", *Healthcare Information Management & Communications Canada,* Vol. 14, Nº 2, pp. 12-14.

Leigh, J. (1983), "Direct and Indirect Effects of Education on Health", Social Science and Medicine, Vol. 17, Nº 4, pp. 227-234.

Leu, R. E. (1986), "The Public-Private Mix and International Health Care Costs," in Public and Private Health Services, A. J. Culyer and Bengt Jönsson (editors), Basil Blackwell: Oxford, pp. 41-63.

Levinsky, N.G., W. Yu, A. Ash, M. Moskowitz, G. Gazelle, O. Savnina and E. J. Emanuel (2001), "Influence of Age on Medical Expenditures and Medicare Care in the Last Year of life", *Journal of the American Medical Association*, Vol. 286, Nº 11, pp. 1349-1355.

Lichtenberg F. (2000), "Sources of U.S. Longevity Increase, 1960–1997", Center for Economic Studies, and Ifo. Institute for Economic Research (CESifo), Working Paper Series, Munich, Germany, working paper Nº 405.

Little, R. J. A. (1992), "Regression with Missing Xs – A Review", *Journal of the American Statistical Association*, Vol. 87, Nº 420, pp. 1227-1237.

Little, R. J. A. and D. B. Rubin (1989), "The Analysis of Social Science Data with Missing Values", *Sociological Methods & Research*, Vol. 18, Nº 2-3, pp. 292-326.

Lubitz, J. D. and G. F. Riley (1993), "Trends in Medicare Payments in the Last Year of Life", *New England Journal of Medicine*, Vol. 328, Nº 15, pp. 1092-1096.

Lubitz, J., J. Beebe and C. Baker (1995), "Longevity and Medicare Expenditure", *The New England Journal of medicine*, Vol. 332, Nº 15, pp. 999-1003.

Maddox, G. L. and E. B. Douglass (1973), "Self-Assessment of Health: A Longitudinal Study of Elderly Subjects", *Journal of Health and Social Behavior*, Vol. 14, Nº 1, pp. 87-93.

Manning, W.G., J. P. Newhouse, N. Duan, E. Keeler, A. Leibowitz and M. S. Marquis (1987), "Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment", *American Economic Review*, Vol. 77, Nº 3, pp. 251-257.

Masseria, C., S. Allin, C. Sorenson, I. Papanicolas and E. Mossialos (2007), "What are the Methodological issues Related to Measuring Health and Drawing Comparisons across Countries?", European Commission, Belgium: Brussels.

Matteo, L. D (2005), "The Macro Determinants of Health Expenditure in the United States and Canada: Assessing the Impact of Income, Age Distribution and Time", *Health Policy*, Vol. 71, Nº1, pp. 23-42.

Maxwell, R. J. (1981), *Health and wealth*, Lexington Books, Lexington.

Maynard, A. and P. Kanavos (2000), "Health Economics: an Evolving Paradigm", *Health Economics*, Vol. 9, Nº 3, pp. 183-190.

McCartney, G., L. Mahmood, A. H. Leyland, G. D. Batty and K. Hunt (2011), "Contribution of Smoking-Related and Alcohol-Related Deaths to the Gender Gap in Mortality: Evidence from 30 European Countries", *Tobacco Control*, Vol. 20, Nº 2, pp. 166-168.

McGrail, K., B. Green, M. L. Barer, R. G. Evans, C. Hertzman and C. Normand (2000), "Age, Costs of Acute and Long-Term Care and Proximity to Death: Evidence for 1987-88 and 1994-95 in British Columbia". *Age and Ageing*, Vol. 29, Nº 3, pp. 249-253.

McGuire, A., D. Parkin and D. Hughes (1993), "Econometric Analyses of National Health Expenditures: Can Positive Economics Answer Normative Questions?" *Health Economics*, Vol. 2, Nº 2, pp. 113–126.

McKeown, T. (1979), *The Role of Medicine: Dream, Mirage or Nemesis*, Oxford: Blackwell.

McKeown, T. and C. R. Lowe (1974), *An Introduction to Social Medicine*, Oxford: Blackwell.

Mehrotra, A., R. A. Dudley and H. S. Luft (2003), "What's Behind the Health Expenditure Trend?" *Annual Review of Public Health,* Vol. 24, pp. 385-412.

Miller R. D. and H. E. Frech (2002), "The Productivity of Healthcare and Pharmaceuticals: Quality of Life, Cause", UC Santa Barbara: Department of Economics, UCSB, University of California, Santa Barbara, www.escholarship.org/uc/item/4b55f1xp, retrieved August 20, 2012.

Miller, R. D. and H. E. Frech (2000), "Is There a Link Between Pharmaceutical Consumption and Improved Health in OECD Countries?", *Pharmacoeconomics*, Vol. 18, Supplement, pp. 33-45.

Miller, R. H., C. West, T. M. Brown, I. Sim and C. Ganchoff (2005), "The Value of Electronic Health Records in Solo or Small Group Practices", *Health Affairs,* Vol. 24, Nº 5, pp. 1127-1137.

Moïse, P. (2003), "The Technology-Health Expenditure Link a Perspective from the Ageing-Related Diseases Study", in A Disease-based Comparison of Health Systems. What is Best and at What Cost?, Organisation for Economic Co-Operation and Development (editor), OECD, Paris, France, Chapter 12, pp. 195-218.

Moïse, P. and S. Jacobzone (2003), "Population Ageing, Health Expenditure and Treatment: An ARD Perspective", in A Disease-based Comparison of Health Systems. What is Best and at What Cost?, Organisation for Economic Co-Operation and Development (editor), OECD, Paris, France, Chapter 10, pp. 163-178.

Mokyr, J. (1997), "Are We Living in the Middle of an Industrial Revolution?" *Federal Reserve Bank of Kansas City Economic Review,* Vol. 82, Nº 2, pp. 31-43.

Moons, K. G., R. A. Donders, T. Stijnen and F. E. Jr. Harre (2006), "Using the Outcome for Imputation of Missing Preditor Values was Preferred", *Journal of Clinical Epidemiology,* Vol. 59, Nº 10, pp. 1092-1101.

Mossey, J. M. and E. Shapiro (1982), "Self-Rated Health: A Predictor of Mortality among the Elderly", *American Journal of Public Health*, Vol. 72, Nº 8, pp. 800-808.

Musgrove, P. (1996), "Public and Private Roles in Health: Theory and Financing Patterns", World Bank Discussion Paper Nº339, Washington.

Mushkin, S. J. (1958), "Toward a Definition of Health Economics", *Public Health Reports*, Vol. 73, Nº 9, pp. 785-93.

Muurinen, J.M. (1982), "Demand for Health: a Generalised Grossman Model", *Journal of Health Economics*, Vol. 1, Nº 1, pp. 5-28.

Nardo, M., M. Saisana, A. Saltelli and S. Tarantola (2005), *Tools for Composite Indicators Building*, European Comission, Ispra.

Newhouse, J. and L. Friedlander, (1980), "The Relationship between Medical Resources and Measures of Health: Some Additional Evidence", *Journal of Human Resources*, Vol. 15, Nº 2, pp. 200-218.

Newhouse, J. P. (1977), "Medical-Care Expenditure: a Cross-National Survey", *Journal of Human Resources*, Vol. 12, Nº 1, pp. 115-125.

Newhouse, J. P. (1992), "Medical Care Costs: How Much Welfare Loss?" *Journal of Economic Perspectives*, Vol. 6, Nº 3, pp. 3-22.

Newhouse, J. P. (1993), "An Iconoclastic View of Health Cost Containment", *Health Affairs*, Vol. 12, Supplement, pp. 152-71.

Newhouse, J. P. and C. E. Phelps (1974), "Price and Income Elasticities for Medical Care Services", in The Economics of Health and Medical Care, M. Perlman (editor), Macmillan, London and Basingstoke.

NICE (2013), http://www.nice.org.uk/website/glossary/glossary.jsp?alpha=Q .accessed in January 2013

Nixon, J. and P. Ullmann (2006), "The Relationship between Health Care Expenditure and Health Outcomes – Evidence and Caveats for a Causal Link", *European Journal of Health Economics*, Vol. 7, Nº 1, pp. 7-19.

Nolen-Hoeksema, S. (2004), "Gender Differences in Risk Factors and Consequences for Alcohol use and Problems", *Clinical Psychology Review*, Vol. 24, Nº 8, pp. 981-1010.

Oksuzyan A, I. Petersen, H. Stovring, P. Bingley, J. W. Vaupel and K. Christensen (2009), "The Male-Female Health–Survival Paradox: a Survey and Register Study of the Impact of Sex-Specific Selection and Information Bias", *Annals of Epidemiology*, Vol. 19, Nº 7, pp. 504-511

Okunade, A. (1985), "Engel Curves for Developing Nations: the Case of Africa", *Eastern Africa Economic Review*, Vol. 1, Nº 1, pp. 13-22.

Okunade, A. A., M. Karakus and C. Okeke (2004), "Determinants of Health Expenditure Growth of the OECD Countries: Jackknife Resampling Plan Estimates", *Health Care Management Science*, Vol. 7, Nº 3, pp. 173-183.

Okunade, A. and V. N. R. Murthy (2002), "Technology as a "Major Driver" of Health Care Costs: a Cointegration Analysis of the Newhouse Conjecture", *Journal of Health Economics*, Vol. 21, Nº1, pp. 147-159.

Or, Z. (2000), "Determinants of Health Outcomes in Industrialized Countries: A Pooled, Cross-country, Time Series Analysis", OECD Economic Studies, Nº 30.

Or, Z. (2001), "Exploring the Effects of Health Care on Mortality Across OECD Countries", OECD Labour Market and Social Policy, Occasional Paper Nº 46, OECD Publishing. http://dx.doi.org/10.1787/716472585704.

Or, Z., J. Wang and D. Jamison (2005), "International Differences in the Impact of Doctors on Health: A Multilevel Analysis of OECD Countries", Journal *of Health Economics*, Vol. 24, Nº 3, pp. 531-560.

Organisation for Economic Co-Operation and Development (1994), "The Reform of Healthcare Systems - a Review of Seventeen OECD Countries", Health Policy Studies Nº 5, Paris.

Organisation for Economic Co-Operation and Development (2003), *A Disease-Based Comparison of Health Systems. What is Best and at What Cost?* OECD: Paris, France.

Organisation for Economic Co-operation and Development (2003), *Health at a Glance – OECD Indicators 2003*, OECD: Paris, France.

Organisation for Economic Co-Operation and Development Health Data (2012), http://www.oecd.org/health/healthdata, accessed in August 2012.

Organisation for Economic Co-operation and Development Health Data (2001), *A Comparative Analysis of 30 Countries*, OECD: Paris, France.

Organization for Economic Co-operation and Development (2009), *Health at a Glance 2009: OECD indicators*, OECD: Paris, France.

Orszag, P. R. (2008), "Growth in Healthcare Costs", http://www.cbo.gov/ftpdocs/89xx/doc8948/01-31-HealthTestimony.pdf, retrieved November 22, 2011.

Oxley, H. and M. MacFarlan (1994), "Healthcare Reform: Controlling Spending and Increasing Efficiency", *OECD Economic Studies*, Vol. 24, pp. 7-55.

Parkin, D., A. McGuire and B. Yule (1987), "Aggregate Health Expenditures and National Income: is Healthcare a Luxury Good?", *Journal of Health Economics,* Vol. 6. Nº 2, pp. 109-127.

Pauly, M. V. (2003), "Should We Be Worried About High Real Medical Spending Growth In The United States?", Health Affairs, http://content.healthaffairs.org/content/early/2003/01/08/hlthaff.w3.15.citation, retrieved November 22, 2011.

Peden, E. A. and M. S. Freeland (1998), "An Analysis of Insurance Effects on Medical Spending: 1960-1993", *Health Economics*, Vol. 7, pp. 671-687.

Phelps, C. (1995), "Perspectives in Health Economics", *Health Economics*, Vol.4, Nº 5, pp. 335-353.

Puig-Junoy, J. (1998), "Measuring Health Production Performance in the OECD", Applied Economic Letters, Vol. 5, Nº 4, pp. 255-259, www.informaworld.com/smpp/content?content=10.1080/135048598354933, retrieved August 09, 2012.

Reinhardt, U.E. (2003), "Does the Aging of the Population Really Drive the Demand for Healthcare?" *Health Affairs*, Vol. 22, Nº 6, pp. 27-39.

Retzlaff-Roberts, D., C. Chang and R. Rubin (2004), "Technical Efficiency in the Use of Health Care Resources: A Comparison of OECD Countries", *Health Policy*, Vol. 69, Vol. 1, pp. 55-72.

Reynolds, R., J. A. Rizzo and M. L. Gonzalez (1987), "The Cost of Medical Professional Liability", *Journal of the American Medical Association*, Vol. 257, Nº 20, pp. 2776-2781.

Ricci, F. and M. Zachariadis (2008), "Longevity and Education Externalities: A Macroeconomics Perspective", LERNA, University of Toulouse, www2.toulouse.inra.fr/lerna/travaux/cahiers2009/09.02.278.pdf, retrieved September 08, 2012.

Robalino, D. A., F. P. Oscar and V. Albertus (2001), "Does Fiscal Decentralization Improve Health Outcomes? Evidence from a Cross-Country Analysis", World Bank Policy research working paper series, Vol. 2565, pp. 1–14.

Roos, N. P., P. Montgomery and L. L. Roos (1987), "Healthcare Utilization in the Years Prior to Death", *Milbank Quarterly*, Vol. 65, Nº 2, pp. 231-254.

Ross, C. E. and C. E. Bird (1994), "Sex Stratification and Health Lifestyle: Consequences for Men's and Women's Perceived Health", *Journal of Health and Social Behaviour*, Vol. 35, Nº2, pp.161-178.

Ross, C. E. and C. Wu (1995), "The Links between Education and Health" *American Sociological Review*, Vol. 60, Nº 5, pp. 719-745.

Rubin, D. B. (1976), "Inference and Missing Data". Biometrika, Vol. 63, Nº 3, pp. 581-590.

Rubin, D. B. (1977), "Formalizing Notions about the Effect of Nonrespondents in Sample Surveys", *Journal of the American Statistical Association*, Vol. 72, Nº 359, pp. 538-543.

Rubin, D. B. (1987), *Multiple Imputation for Nonresponse in Surveys*, New York: Wiley.

Rubin, D. B., and N. Schenker (1991), "Multiple Imputation in Health-Care Databases: An Overview and Some Applications", *Statistics in Medicine*, Vol. 10, Nº 4, pp. 585-598.

Ruhm, C. J. (2000), "Are Recessions Good for your Health?", *Quarterly Journal* of *Economics, Vol.* 115, Nº 2, pp. 617-50. DOI: 10.1162/003355300554872.

Ruhm, C. J. (2003), "Good Times Make you Sick", *Journal of Health Economics*, Vol. 22, Nº 4, pp. 637-58. DOI: 10.1016/S0167-6296(03)00041-9.

Ruhm, C. J. (2005), "Commentary: Mortality Increases During Economic Upturns", *International Journal of Epidemiology*, Vol. 34, Nº 6, pp. 1206-1211. DOI: 10.1093/ije/dyi143.

Sanders, B. S. (1964), "Measuring Community Health Levels", *American Journal of Public Health and Nations Health*, Vol. 54, Nº 7, pp. 1063-1070.

Santerre, R. E., G. G. Stephen and J. S. Andrew (1991), "Government Intervention in Health Care Markets and Health Care Outcomes: Some International Evidence", *Cato Jourrnal*, Vol. 11, Nº 1, pp. 1-12.

Schafer, J. L. (1999), "Multiple Imputation: A primer", Statistical Methods in Medical Research, Vol. 8, Nº 1, pp. 3-15.

Schafer, J. L. and M. K. Olsen (1998), "Multiple Imputation for Multivariate Missing-Data Problems: A data Analyst's Perspective", *Multivariate Behavioral Research*, Vol. 33, Nº 4, pp. 545-571.

Schafer, J.L. (1997), *Analysis of Incomplete Multivariate Data*, Boca Raton, FL: Chapman & Hall/CRC.

Scherer, E. M. (2000), "The Pharmaceutical Industry", in Handbook of Health Economics, Volume 1B, A. J. Culyer and J. P Newhouse (editors), Elsevier Science B. V. Chapter 25, pp. 1297-1336.

Schulz, E., R. Leidl and H. König (2004), "The Impact of Ageing on Hospital Care and Long-Term Care – The example of Germany", *Health Policy*, Vol. 67, Nº 1, pp. 57-74.

Schwellnus, C. (2009), "Achieving Higher Performance: Enhancing Spending Efficiency in Health and Education in Mexico", OECD Economics Department Working Papers, Nº 732.

Self, S. and R. Grabowski (2003), "How Effective is Public Health Expenditure in Improving Overall Health? A Cross-country Analysis", *Applied Economics*, Vol. 35, Nº 7, pp. 835-845.

Serup-Hansen, N., J. Wickstrøm and I. S. Kristiansen (2002), "Future Healthcare Costs – Do Healthcare Costs During the Last Year of Life Matter?", *Health Policy*, Vol. 62, Nº 2, pp. 161-172.

Seshamini, M. and A. M. Gray (2004 a), "Ageing and Healthcare Expenditure: the Red Hering Argument Revisited", *Health Economics*, Vol. 13, Nº 4, pp. 303-314.

Seshamini, M. and A. M. Gray (2004 b), "A Longitudinal Study of the Effects of Age and Time to Death on Hospital Costs", *Journal of Health Economics*, Vol. 23, Nº 2, pp. 217-235.

Shaw, J. W., W. C. Horrace and R. J. Vogel (2002), "The Productivity of Pharmaceuticals in Improving Health: An Analysis of the OECD Health Data", WUSTL Economics Working Paper, HEW series, http://129.3.20.41/eps/hew/papers/0206/0206001.pdf, retrieved August 10, 2012.

Shields, M. and S. Shooshtari (2001), "Determinants of Self-Perceived Health", *Health Reports*, Vol. 13, Nº 1, pp. 35-52.

Shrive, F. M., H. Stuart, H. Quan and W. A. Ghali (2006), "Dealing with Missing Data in a Multi-Question Depression Scale: a Comparison of Imputation Methods", *BMC Medical Research Methodology*, Vol. 6: 57.

Shumpeter, J. A. (1933), "The common sense of econometrics", *Econometrica*, Vol. 1, pp. 5-12.

Siddiqui, R. and Mahmood, M. A. (1994) "The Determinants of Health Status: A Cross Country Analysis", *Pakistan Development Review*, Vol. 33, Nº 4 Part II, pp. 745-758.

Silver, M. (1972), "An Econometric Analysis of Spatial Variations in Mortality Rates", in Essays in the Economics of Health and Medical Care, V. Fuchs (editor), National Bureau of Economic Research: Colombia University Press, New York, pp. 161-227.

Smith, S. D., S. K. Heffler and M. Freeland (2000), "The Impact of Technological Change on Healthcare Costs Spending: An Evaluation of the Literature", https://www.cms.gov/NationalHealthExpendData/downloads/tech_2000_0810.pdf, retrieved November 22, 2011.

Soares, R. R. (2007), "Health and the Evolution of Welfare across Brazilian Municipalities", *Journal of Development Economics*, Vol. 84, Nº 2, pp. 590-608.

Spillmann, B. and J. Lubitz (2000), "The Effect of Longevity on Spending for Acute and Long-Term Care", *The New England Journal of Medicine*, Vol. 342, Nº 19, pp. 1409-1415.

Spinks, J. and B. Hollingsworth (2009), "Cross-Country Comparisons of Technical Efficiency of Health Production: a Demonstration of pitfalls", *Applied Economics*, Vol. 41, Nº 4, pp. 417-427.

Stahl, I. (1986), *Can Healthcare Costs be Controlled?* Umversltetsforlaget, Lund University, Sweden.

Stearns, S. C. and E. C. Norton (2004), "Time to Include Time to Death? The Future of Healthcare Expenditure Predictions", *Health Economics*, Vol. 13, Nº 4, pp. 315-27.

Stigler, G. J. (1971), "The Theory of Economic Regulation", *Bell Journal of Economics and Management Sciences*, Vol. 2, Nº 1, pp. 137-46.

Substance Abuse and Mental Health Services Administration (2010), "National Survey on Drug Use and Health", http://www.oas.samhsa.gov/nhsda.htm, retrieved November 08, 2012.

Sullivan, D. F. (1971a), "A Single Index of Mortality and Morbidity", *HSMHA Health Report*, Vol. 86, Nº 4, pp. 347-54.

Sullivan, D. F. (1971b), "Disability Data Components for an Index of Health", PHS Publication Nº 1000, Series 2, Nº 42, U.S. Government Printing Office, Washington, D.C. In press.

The Economist, (2005, April 30), "The No-Computer Virus – IT in the Health-Care Industry", *The Economist,* Vol. 375, Nº 8424, pp. 72, U.S. Edition.

Thornton, J. (2002), "Estimating a Health Production Function for the US: Some New Evidence", *Applied Economics*, Vol. 34, Nº 1, pp. 59-62

Torrance, G. (1986) "Measurement of Health State Utilities for Economic Appraisal: A Review", *Journal of Health Economics*, Vol. 5, Nº 1, pp. 1-30.

Tosetti, E. and F. Moscone (2007), "Health Expenditure and Income in the United States", University of Leicester, Department of Economics Working Paper Nº 07/14, October 2007.

Towse, A. and C. Pritchard (2002), "National Institute for Clinical Excellence (NICE): Is economic appraisal working?" *Pharmacoeconomics***,** Vol. 20, Supplement 3, pp. 95-105.

Turner, J. R. and D. Lloyd (1995), "Lifetime Traumas and Mental health: The Significance of Cumulative Adversity", *Journal of Health and Social Behaviour*, Vol. 36, Nº 4, pp. 360-376.

Van Buuren, S., H. C. Boshuizen and D. L. Knook (1999), "Multiple Imputation of Missing Blood Pressure Covariates Insurvival Analysis", *Statistics in Medicine*, Vol. 18, Nº 6, pp. 681-694.

Van der Heijeden, G. J., A. R. Donders, T. Stijnen, T. and K. G. Moons (2006). "Imputation of Missing Values is Superior to Complete case Analysis and the Missing-Indicator Method in Multivariable Diagnostic Research: a Clinical Example", *Journal of Clinical Epidmiology*, Vol. 59, Nº 10, pp. 1102-1109.

Verhoeven, M., V. Gunnarsson and S. Carcillo (2007), "Education and Health in G7 Countries: Achieving Better Outcomes with Less Spending", IMF Working Paper, Nº 07/263, www.imf.org/external/pubs/cat/longres.cfm?sk=21444.0, retrieved September 08, 2012.

Wagstaff, A. (1986), "The Demand for Health: Some New Empirical Evidence", *Journal of Health Economics*, Vol. 5, Nº 3, pp. 195-223.

Waldron, I. (1985), "What do we know about Causes of Sex Differences in Mortality? A Review of the Literature", Population Bulletin of the United Nations, Vol. 18, pp. 59-76.

Watson, R. J. (1977), "A Large-Scale Professionally Oriented Medical Information System – Five Years Later", *Journal of Medical Systems*, Vol. 1, Nº 1, pp. 3-21.

Weil, T. P. (1995), "Comparisons of Medical Technology in Canadian, German and US Hospitals", *Hospital and Health Services Administration*, Vol. 40, Nº 4, pp. 524-533.

Weisbrod, B.A. (1991), "The Healthcare Quadrilemma: an Essay on Technological Change, Insurance, Quality of Care, and Cost Containment", *Journal of Economic Literature*, Vol. 29, Nº 2, pp. 523-552.

Wilkie, J. and A. Young (2009), "Why Health Matters for Economic Performance", Economic Round-up, Nº 1, pp. 57-72, http://www.apo.org.au/node/1239, retrieved September 08, 2012.

Williams, A. (1993), "Priorities and Research Strategy in Health Economics for the 1990", *Health Economics,* Vol. 2, Nº 4, pp. 295-302.

Williams, A. (1998), "A Primeval Health Economics in Britain: a Personal Retrospect of the Pre-HESG (Health Economists' Study Group) period", *Health Economics,* Vol. 7, Supplement 1, pp. S3-S8.

Wingard, D. L. (1984), "The Sex Differential in Morbidity, Mortality, and Lifestyle", *Annual Review of Public Health,* Vol. 5, pp. 433-458.

Wolfe B. L. and M. Gabay (1987), "Health Status and Medical Expenditures: More Evidence of a Link", *Social Science and Medicine*, Vol. 25, Nº 8, pp. 883-888.

Wolfe, B. L. (1986), "Health Status and Medical Expenditures: is There a Link?" *Social Science and Medicine*, Vol. 22, Nº 10, pp. 993-999.

World Health Organization (1948), "Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference", New York, 19-22 June, signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 19.

World Health Organization (1998), "Health Promotion Glossary", available at http://www.who.int/healthpromotion/about/HPR_Glossary_1998.pdf.

World Health Organization (2001), *Macroeconomics and Health: Investing in health for economic development, Report of the commission on macroeconomics and health*, WHO, Geneva.

World Health Organization (2006), *Building foundations for eHealth: Progress of member states: Report of the Global Observatory for eHealth,* France: World Health Organization.

World Health Organization (2010), *World Health Statistics 2010*, France: World Health Organization.

World Health Organization (2013 a), www.who.int/healthinfo/statistics/indhale/en/.

World Health Organization (2013 b), www.who.int/mental_health/management/depression/daly/en/, accessed in January 2013

World Health Organization, (2010), *The World Health Report 2001*, Geneva: WHO.

Yuan, Y. C. (2000), "Multiple Imputation for Missing Data: Concepts and new Development", In Proceedings of the Twenty-Fifth Annual SAS Users Group International Conference (Paper No. 267), Cary, NC: SAS Institute.

Zhou, X. H., G. J. Eckert and W. M. Tierney (2001), "Multiple Imputation in Public Health Research", *Statistics in Medicine*, Vol. 20, Nº 9-10, pp. 1541-1549.

Zweifel, P., S. Felder, and M. Meiers (1999), "Ageing of Population and Healthcare Expenditure: A Red Herring?", *Health Economics*, Vol. 8, Nº 6, pp. 485-496.